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HOUSEHOLD AND STORED-FOOD INSECTS OF PUBLIC HEALTH IMPORTANCE AND THEIR CONTROL. TRAINING GUIDE

Harold George Scott

Communicable Disease Center
Atlanta, Georgia

May 1963

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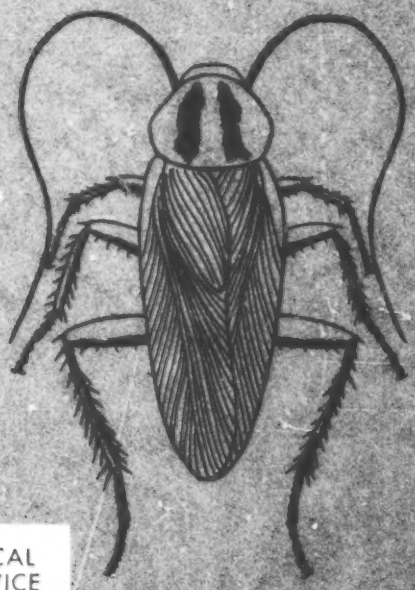

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HOUSEHOLD AND STORED-FOOD INSECTS OF PUBLIC HEALTH IMPORTANCE AND THEIR CONTROL

TRAINING GUIDE – INSECT CONTROL SERIES

Harold George Scott, Ph. D.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Atlanta, Georgia

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INTRODUCTION

This is an age of insects. Insects are the predominant form of life on earth today. Man, using intelligence to guide his grasping hand, wrests food and shelter from his environment. Insects, utilizing diversity and overwhelming numbers, steal man's food, infest his dwellings, and damage his property. Through the centuries an increasing number of insects have become adapted to indoor life (Hatch, 1953) preferring buildings because of the moderate temperature, plentiful food and water, and abundant harborage. Insects, aided, by domestic rodents, rob the citizens of the United States of more than $1 billion worth of stored food annually, contaminating and spoiling far more than they eat. When present in a restaurant or store, they may repel customers and cause additional economic loss. They damage clothing, rugs, and other items. They cause disease in and transmit disease to man and his domestic animals (Parkin, 1956). Public health workers should be able to recognize common household species, know their public health importance, and be able to recommend effective control procedures.

PUBLIC HEALTH IMPORTANCE

DIRECT EFFECTS

Bed bugs, kissing bugs, spiders, centipedes, fleas, ants, and others *bite*. Scorpions, some ants, bees, wasps, and others *sting*. Millipedes and blister beetles exude *blistering fluid*. Flies, beetles, moths, and mites *infest* human flesh or intestines. In addition, household and stored food pests cause *annoyance* and, in extreme cases, *entomophobia* (table 12.1 and 12.2).

MECHANICAL TRANSMISSION OF DISEASE

Many household and stored-food insects travel between likely sources of human disease germs (privies, sewers, garbage, etc.) and food destined for human consumption. They carry germs on their feet, body hairs, mouthparts, and in their intestines (fig. 12.1, table 12.2 and 12.3).

BIOLOGICAL TRANSMISSION OF DISEASE

In some cases the insect plays an essential part in the life cycle of the parasite, and biological transmission of disease occurs (table 12.4).

Table 12.1—Deaths from venomous animals in the United States, 1950–59 (after Parrish, 1963)

		Number	*Percent*
Hymenopterous insects		229	49.8
Bees	124		
Wasps	69		
Yellow jackets	22		
Hornets	10		
Ants	4		
Poisonous snakes		138	30.0
Rattlesnakes	94		
Cottonmouth moccasins	8		
Coral snakes	2		
Exotic and unidentified snakes	34		
Spiders		65	14.1
Scorpions		8	1.7
Coelenterata (jellyfish, Portuguese man-of-war)		1	0.2
Stingaree (sting ray)		1	0.2
Animal or insect, unknown		18	3.9
Total		460	99.9

Figure 12.1

Table 12.2—Some human diseases caused directly by household and stored-food pests

VANILLISM (VANILLA ITCH), COPRA ITCH, GROCER'S ITCH, GRAIN ITCH, severe dermatitis conditions caused by the bites of stored-food mites.

INTESTINAL ACARIASIS, infestation of the intestine by cheese mites, sugar mites, floricolus grain mites, or other stored-food mites.

INTESTINAL CANTHARIASIS, infestation of the intestine by larvae of the yellow mealworm, or other stored-food beetles.

INTESTINAL MYIASIS, infestation of the intestine by the cheese maggot or other domestic flies.

MILL DUST ALLERGY, associated with stored-food insect fragments in milldust.

Table 12.3.—Some human diseases transmitted mechanically by household and stored-food pests

ENTERIC DISEASES (dysenteries, diarrheas), caused by bacteria or protozoa, transmitted from man to man by cockroaches and other domestic pests (fig. 12.1, 12.5).

DWARF TAPEWORM DISEASE, caused by *Hymenolepis nana*, transmitted from the house mouse to man by rodent fleas and mealworms (fig. 12.2).

RAT TAPEWORM DISEASE, caused by *Hymenolepis diminuta*, transmitted from domestic rodents to man by rodent fleas, cockroaches, and mealworms (fig. 12.3).

DIPYLIDIASIS, caused by *Dipylidium caninum* tapeworms, transmitted from dog to man by infected fleas (fig. 12.4).

Table 12.4.—Some human diseases transmitted biologically by household and stored-food pests

PLAGUE, caused by *Pasturella pestis* bacteria, transmitted from rodents to man by bites of infected rat fleas. Many outbreaks involve fleas in shipments of rice (fig. 12.7).

MURINE TYPHUS, caused by *Rickettsia typhi*, transmitted from rats to man by infected feces of rat fleas being rubbed into abraded skin.

RICKETTSIALPOX, caused by *Rickettsia akari*, transmitted from house mice to man by bites of infected house mouse mites.

CHAGAS DISEASE, caused by *Trypanosoma cruzi* protozoa, transmitted from rodents and other mammals to man by bites of infected kissing bugs.

LIFE CYCLE of—

Hymenolepis nana

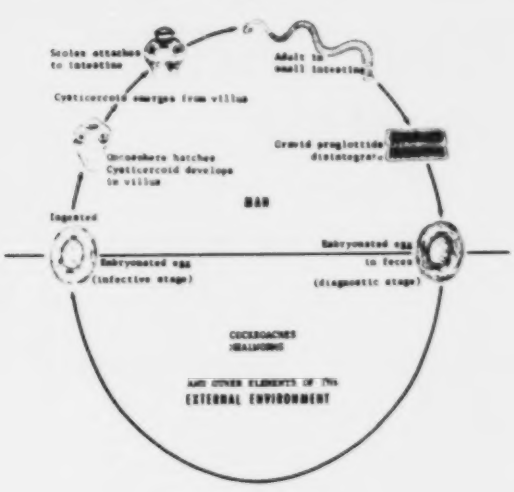

Figure 12.2

LIFE CYCLE of—

Hymenolepis diminuta

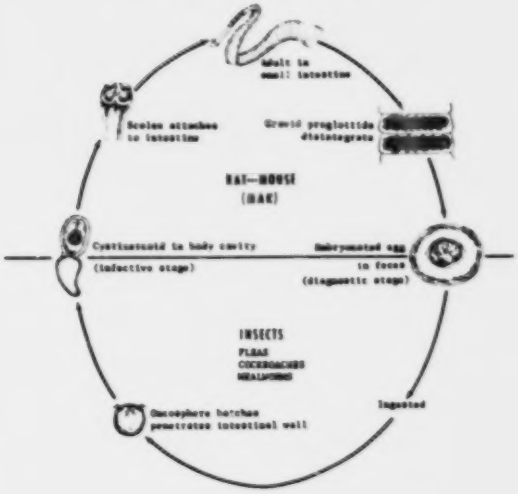

Figure 12.3

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LIFE CYCLE of—

Dipylidium caninum

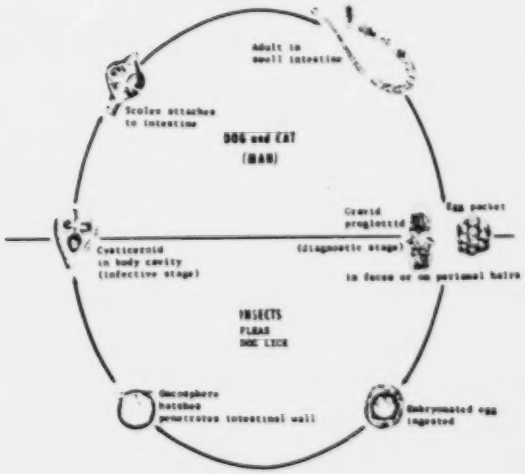

Figure 12.4

FOOD-BORNE DISEASE ROUTES

DISEASE ORGANISMS FROM ——→ MAY TRAVEL IN OR ON ——→ TO YOU

Figure 12.5

COMMON SOURCES OF BIRD, BAT, AND RODENT ECTOPARASITES ANNOYING TO MAN

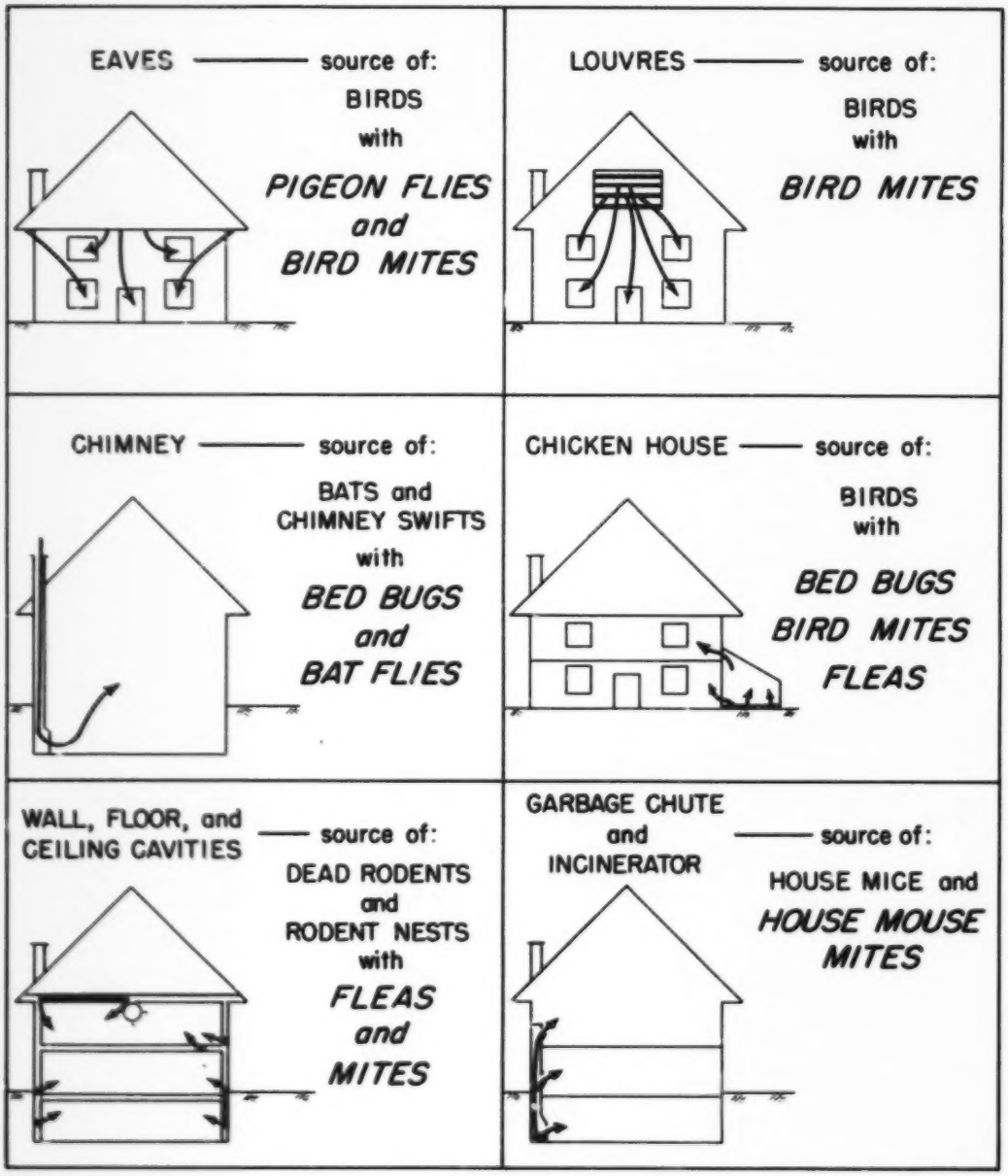

Figure 12.6

LIFE CYCLE of—

Trypanosoma cruzi

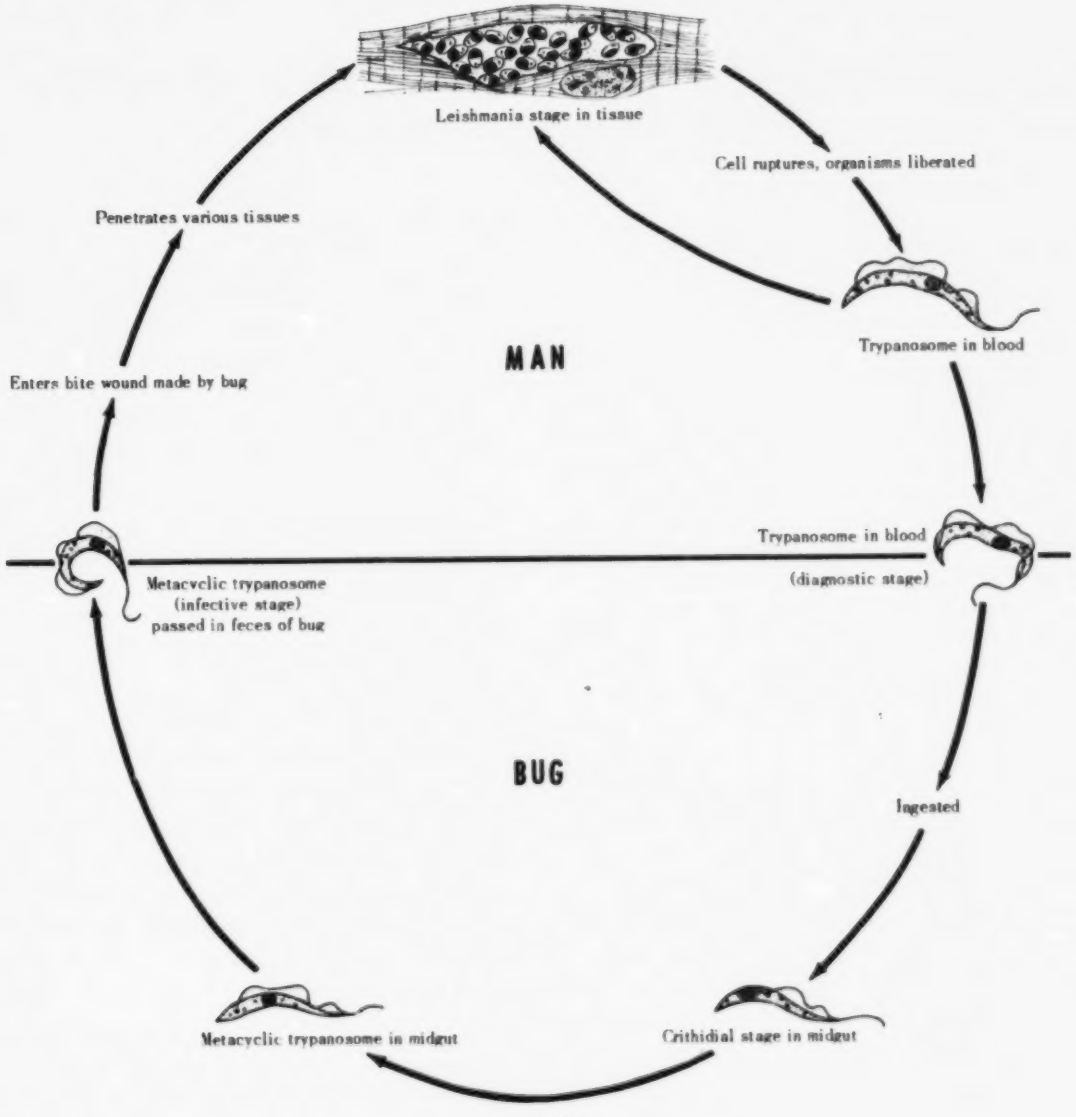

Figure 12.7

HOUSEHOLD AND STORED-FOOD INSECTS OF MAJOR PUBLIC HEALTH IMPORTANCE

KISSING BUGS

Class Insecta, Order Hemiptera, Family Reduviidae

The term kissing bug is applied to those members of the insect Order Hemiptera (true bugs) belonging to the Subfamily Triatominae (Family Reduviidae). They are also called "conenose bugs," "bloodsucking conenoses," "assassin bugs," and "triatoma bugs." All kissing bugs are parasitic upon (suck the blood of) mammals and birds. They also attack other blood-feeding insects and suck the blood from them.

Nine species of kissing bugs are known from the United States. Seven commonly bite or are involved in the transmission of disease to man (fig. 12.8).

Kissing bugs parallel bed bugs (fig. 12.10) in their habits. They usually remain hidden in the nest of their host, coming out to feed only when the host is asleep. The bugs usually invade the home of man from a rodent nest or other mammal or bird nest near, on, under, or in the house.

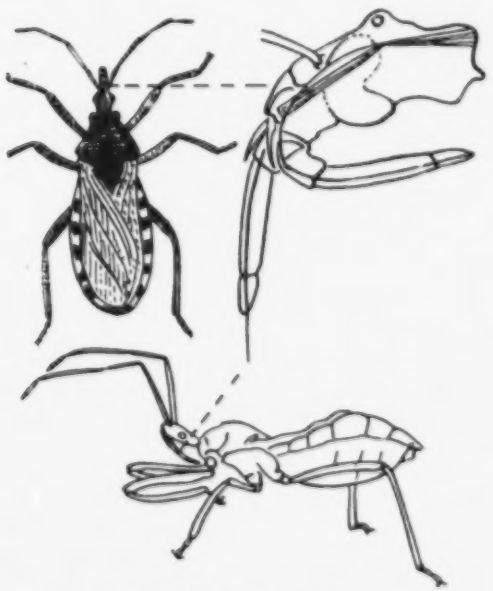

Figure 12.8 Kissing Bug

The bugs harbor in and around the bed, particularly between the mattress and sheet or mattress and mattress cover. Wood-to-wood joints in the bed and other bedroom furniture may encourage development of an infestation. Upholstered furniture may also be involved.

Since kissing bugs resemble plant feeding bugs, they may be ignored by, or simply picked up and thrown out by householders. Few people in the United States are aware of the bloodsucking habits or disease transmission potential of these insects. Yet kissing bugs probably occur regularly in houses in the southern half of the United States.

Should a kissing bug be found on the face or limbs, it should be brushed off gently, since it is apt to bite severely if pinched or crushed.

DEVELOPMENT

Kissing bugs undergo incomplete metamorphosis: egg to nymph to adult. The adult female lays from 100 to 300 eggs which hatch in 2 or 3 weeks into nymphs (wingless replicas of the adult). The nymph molts five times, always after a blood meal, and becomes an adult in 1 or 2 years. Shortly after reaching maturity, each female is fertilized by a male and the life cycle recurs.

CHAGAS DISEASE

Chagas disease is caused by haemoflagellate protozoa, *Trypanosoma cruzi*, which is transmitted from mammal to mammal via the feces of infected kissing bugs. Infection occurs through conjunctivae, mucous membranes, abrasions, or wounds in the skin including the site of the bug bite. Mammals involved include dogs, cats, wood rats, opossums, and armadillos (fig. 12.7).

Illness occurs about 7 to 14 days after infection. The introduced protozoa invade the peripheral blood, muscles, and other tissues. In man, the acute stage of the disease, lasting several weeks, involves fever, malaise, enlargement of spleen and liver, and damage to heart

muscle. Unilateral edemal inflammation and discoloration of the eyelids and face (Romaña's sign) is an important early indication of the disease. Chagas disease may become chronic with brain damage or may end with gradual heart muscle failure. Children, especially those under 2 years of age, are especially susceptible. Mild and subclinical cases also occur.

The disease is diagnosed by (1) demonstrating *Trypanosoma cruzi* protozoa in the blood or muscle, (2) inoculating mice and subsequently diagnosing the disease in the mice, or (3) feeding "clean" kissing bugs on the febrile patient and 2 weeks later demonstrating *Trypanosoma cruzi* in the hind-gut of the bugs (xenodiagnosis).

Chagas disease has occurred in widespread epidemics in South and Central America with thousands, perhaps millions of human cases and thousands of deaths recorded between 1909 and 1961 (Dias and Chandler, 1949). Only a few human cases have been verified in the United States, but the disease has been found in wild mammals and/or kissing bugs in 8 States, and potentially it could occur natively in 27 States (fig. 12.9).

ENVENOMIZATION

Kissing bugs bite with their slender 3-segmented beaks, injecting saliva in order to keep the host's blood from clotting. At the time of biting, little sensation is experienced by the victim, but later the site of the bite may become greatly inflamed and highly painful as a result of haemorrhagic saliva of the bug. This time lapse between bite and the host's realization he has been bitten assists kissing bugs in avoiding detection.

Kissing bug bite occurs regularly in infested areas. Affected individuals come from all economic levels. Reaction to bites seems to involve sensitization (i.e., the first bite produces mild reaction, but sensitizes the host so that later bites produce greater reaction), with the host gradually becoming desensitized (i.e., immune to the effects of the bite). Severity of the bite is also correlated with quantity of saliva introduced—the

CHAGAS' DISEASE DISTRIBUTION IN THE UNITED STATES

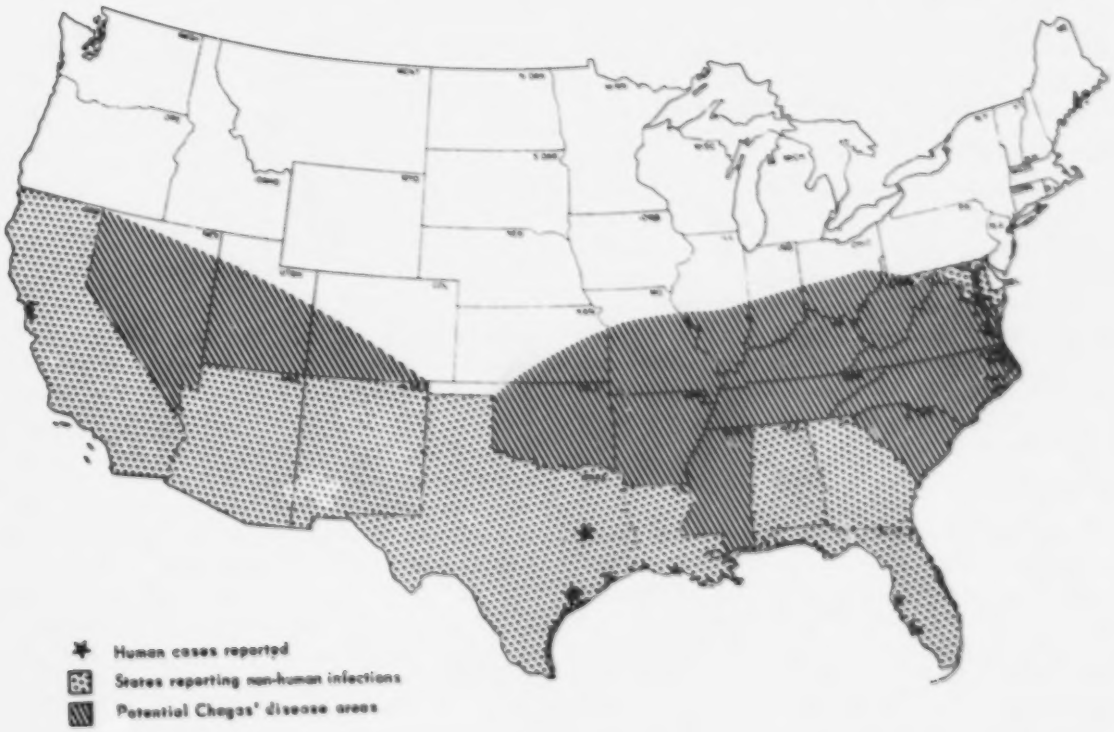

Figure 12.9

greater the amount of saliva, the more severe the reaction.

Failure of antibiotics to affect kissing bug bites indicates secondary infection does not produce the symptoms. However, all kissing bug bites should be disinfected as soon as noticed. Four types of bite reaction are recognized (from least to most severe):

(1) Pimple-like lesions. When occurring in groups, these lesions resemble the virus skin disease herpes zoster.
(2) Small blisters grouped over an area about 1 inch in diameter, with moderate swelling and little redness.
(3) Giant inflamed red wheals, about 6 inches across, swollen with fluid. Inflammation of the lymph glands and vessels may occur.
(4) Multiple haemorrhagic knotty-to-knobby lesions. Lymph gland and vessel inflammation often occurs.

Some other bugs, closely related to kissing bugs are capable of inflicting a venomous bite on man. For example, the bite of the wheel bug, *Arilus cristatus* (page 36) is extremely painful and can produce severe damage (Smith, 1958). When venomous bugs bite man, intense pain is usually felt immediately as opposed to the delayed reaction associated with kissing bug bites (Wray, 1959). Most venomous relatives of kissing bugs are beneficial, being predaceous on insect pests.

IDENTIFICATION

Kissing bugs resemble plant feeding bugs, but may be distinguished from them by the nature of the proboscis (beak). Kissing bugs have a three-segmented proboscis while other similar-appearing bugs have a four- or five-segmented proboscis (page 36). Identification of U.S. species of kissing bugs is based upon size, pattern, distribution of setae (hairs), and relative size of body parts. The pictorial key (page 37) defines all U.S. species known to be suitable vectors of chagas disease.

CONTROL

Environmental control involves elimination of cracks and crevices where kissing bugs harbor. Avoid bedroom furniture with wood-to-wood joints. Keep home free of rodents and other wild mammals and birds.

Chemical control involves spraying infested dwellings meticulously with 5 percent DDT emulsion, giving special attention to cracks and crevices in and near beds and upholstered furniture. Dust rodent burrows, and other mammal and bird harborage with 10 percent DDT. Kissing bug resistance to DDT has not been demonstrated, but in the event of such resistance, use 1 percent lindane emulsion indoors and 3 percent malathion outdoors.

In large scale control programs an anticoagulant rodenticide bait containing a systemic insecticide might prove effective in killing kissing bugs prior to the death of their rodent hosts (Bennington, 1960). This would keep dispossessed bugs from biting and spreading disease to humans. In any case, provision should be made for control of kissing bugs prior to control of the hosts.

After emergency control of the kissing bugs and their hosts, attention should be given to environmental sanitation (Johnson, 1960) and suitable stoppage to prevent reinfestation.

BED BUGS

Class Insecta, Order Hemiptera, Family Cimicidae

THE BED BUG, *Cimex lectularius*, has been prevalent in Europe for centuries and in this country since early colonial days although apparently unknown

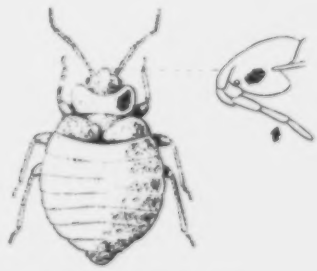

Figure 12.10. Bed Bug

to the American Indian. The adult is 1/5-inch long, 1/8-inch wide, and reddish brown in color. The flattened oval body is adapted for hiding in narrow crevices. The head bears a pair of four-segmented antennae and piercing-sucking mouthparts which fold to lie between the first pair of legs. The wings are represented by pads. The body may become greatly enlarged and blood red in color during the taking of a blood meal. From 1 to 5 eggs are laid per day over a period of 2 to 10 months until approximately 200 are deposited. The eggs are cemented to bedding or in cracks. Development from the egg through a series of nymphs to the adult takes 18 to 56 days, and the adults normally live 6 months to a year. A blood meal must be taken before each molt. The female may live nearly a year without food and can endure freezing

temperatures for considerable time. Bed bugs are found on the clothing and possessions of infested individuals. They may be found on poultry and may be abundant in farmer's markets. A heavily infested house has a distinctive odor. Some people are very sensitive to bed bug bites while others are hardly aware of them. Immediately after feeding, the bed bug defecates, passing out the semisolid sticky remains of the last meal. This material may enter the bite injury, but as yet the insect has not been incriminated in the transmission of any communicable disease. Bed bugs may cause nervous disorders in sensitive people, and may contribute to the ill health of both children and adults. Man is the preferred host, but bed bugs will feed readily on poultry, mice, rats, and other animals.

COCKROACHES

Class Insecta, Order Orthoptera, Family Blattidae

Cockroaches have become well-adjusted to living with man. They harbor in the cracks and crevices provided by human building methods. They subsist on the bits of food man scatters where he lives or travels. Cockroaches have been reported nibbling on the eyelashes, fingernails, and toenails of sleeping children. They impart an unsavory odor and taste into food they infest. Cockroaches are predaceous on bed bugs. They carry the organisms causing enteric diseases (diarrhea, dysentery, typhoid, food poisoning) from sewers and garbage cans to the food of man (Schoof and Siverly, 1954) and have been found naturally infected with many other pathogens (Roth and Willis, 1957).

Cockroaches have three life stages: egg, nymph, and adult. The eggs are deposited in a capsule or ootheca. When the tiny nymphs emerge, they resemble adult cockroaches but do not have wings. Growth occurs during a succession of molts, and mature males and females appear at the last molt. The wings of the adults may or may not be functional. Most cockroaches are nocturnal, appearing during daylight only when disturbed. They prefer warm moist situations such as cracks and crevices near stoves and coffee urns, and wall surfaces near steam pipes. They are accomplished travelers, having been distributed world-wide on ships and aircraft. Some tropical species subsist upon vegetation, but most domestic species are scavengers finding an abundance of food and harborage in the home of man. They are fond of starchy materials such as cereals, bakery products, and book bindings. They also feed upon beer, cheese, leather, wallpaper, and dead animals. Cockroaches expel unpleasant secretions that spoil the flavor of foods. They regurgitate fluid from their mouths while feeding and deposit feces loaded with bacteria. Persons with a keen sense of smell are able to detect the presence of even a few cockroaches in a restaurant, while almost anyone can detect a heavy infestation. Cockroaches have few natural enemies and can survive in highly sanitary kitchens and restaurants (Gould and Deay, 1940). The sex of the adult can be determined by noting, in the male, unsegmented *styli* (paired appendages at the end of the abdomen smaller than the segmented *cerci*).

THE AMERICAN COCKROACH, *Periplaneta americana*, originated in tropical Africa but is now distributed world-wide. The ootheca is dropped at random or attached to a curtain, wall, or other surface. Pressure exerted by the young cockroaches in the ootheca causes it to open along the seam. Young emerge from the egg, emerge from the capsule, and molt all within 10 minutes. The white young nymphs soon become grayish brown, and gradually attain a characteristic mahogany color as they mature. The American cockroach is capable of flights of a gliding nature. It is found in alleyways, yards, sewerage systems, and trees. It frequently enters buildings under

Table 12.5—Statistics on common cockroach species

Common name of cockroach	Average number of eggs in ootheca	Average number of oothecae deposited per female	Number of molts	Length of life cycle (room temp.) (days)	Average longevity of adult (days)
American	15	58	10–13	320–1,071	441
Australian	24	.....	10–12	av. 270	.....
Smoky brown	20	17	9–12	202–514	247
German	37	7	5–7	64–231	140
Brown-banded	16	10	7–9	143–379	115
Oriental	14	14	7–10	215–991	96
Wood	26	15	.....	286–776	145

doorways. It prefers warm resting places such as steam tunnels and basements during the winter months, and causes damage to book bindings, manuscripts, clothing, glossy paper with starch sizing, and labels from bottles. It is often trapped in vessels containing beer, syrup, or sweetened drinks.

THE AUSTRALIAN COCKROACH, *Periplaneta australasiae,* is found chiefly in Florida and southern California but sometimes appears in greenhouses and houses farther north where it often does a considerable amount of damage. It seldom flies.

THE SMOKY-BROWN COCKROACH, *Periplaneta fuliginosa,* flies readily and feeds chiefly on plant materials, damaging greenhouse stock as far north as Indiana. It is common in wooded areas near houses. Seasonal migrations or infested firewood may bring it into houses.

THE BROWN COCKROACH, *Periplaneta brunnea,* is found in the southern United States from Florida to Texas, and occurs occasionally in other States. It is often confused with the American cockroach, which it resembles not only in appearance but in habits.

THE GERMAN COCKROACH, *Blattella germanica,* is probably the commonest cockroach found in restaurants. It is sometimes called the "croton bug." This pest enters the home with bottled drinks, potatoes, onions, other foods, and furniture. Both sexes are fully winged but rarely fly. This cockroach is more active than other domestic species, produces more eggs per capsule, and has a relatively short development period. It is the only domestic species in which the female carries the egg case until it is ready to hatch. Capsules do not hatch if detached more than a day or so before hatching. German cockroach resistance to chlordane is widely reported.

THE BROWN-BANDED COCKROACH, *Supella supellectilium,* is tropical in origin, and it has only recently become an important household species. It was reported in Miami, Fla., in 1903, and is now known to occur as far north as Canada. The brown-banded cockroach is difficult to control because it does not confine its activities to the kitchen, bathroom, and pantry but is found throughout the house. It has the habit of hiding oothecae in furniture, probably accounting for its rapid spread northward. This species is active, and the adults fly readily when disturbed. The egg capsule is plump and measures approximately 3/16 inch in length and one-half as much in width. It is yellowish or reddish brown in color, and the fertile egg often shows greenish through the walls.

THE ORIENTAL COCKROACH, *Blatta orientalis,* a dark brown or black species found throughout the United States, appears to be increasing in abundance. It may be in damp basements, along sewer lines, in theaters, around leaks, and under ice boxes. Being less domestic than most of the other species, "wild" colonies are common in yards and out-buildings. Spring and fall migrations may be noted. It is not known to fly. It has been found as far north as North Dakota.

THE PENNSYLVANIA WOOD ROACH, *Parcoblatta pennsylvanica,* is a small species which may be brought into the home with firewood. The adults are brownish black with the lateral edges of the thorax and basal half to three-fourths of the wings margined with yellow. The wings of the male are no longer than the body, but those of the female cover only one-third to two-thirds of the abdomen. Other wood roaches may also be found in houses, but only rarely.

THE MADEIRA COCKROACH, *Leucophaea maderae,* a large species, first introduced into New York City from the West Indies about 1940, is not generally distributed, but is found in apartment houses where recent immigrants from Puerto Rico have settled. The species is about 2 inches in length, with a tan, mottled color with black lines. Adults can fly but are usually sluggish in the cool climate of New York City.

BEETLES AND MOTHS INFESTING WHOLE GRAIN

THE RICE WEEVIL, *Sitophilus oryza,* world-wide in distribution, is probably the most important grain pest. This small, reddish-brown to black snout beetle, 1/8 to 1/6 inch long, has small, round pits on the thorax and two reddish or yellowish spots on each wing cover. The larva is short, fat, and whitish. The adult is a strong flier. The larva and pupa develop within a single grain of rice or kernel of corn, from which the adult weevil emerges about 30 days after the egg is laid. The adult female lives 4 to 5 months, depositing 300 to 400 eggs in small openings bored into grain. The rice weevil feeds upon corn, rice, wheat, barley, and other grains.

THE GRANARY WEEVIL, *Sitophilus granarius,* is similar to the rice weevil in appearance, but with oval pits on the thorax, and with the wing covers uniformly dark brown. This insect has become thor-

oughly domesticated, losing its power of flight and forsaking wild and cultivated grain fields for the grain storehouses of man. This snout beetle is slightly larger than the rice weevil and lives from 7 to 8 months. Whereas the rice weevil is a major pest in the South, the granary weevil more often frequents the Northern States.

THE CADELLE, *Tenebroides mauritanicus,* is a black beetle ⅓ to ½ inch long, with the head and pronotum distinctly separated from the forewings by a loose joint. The large, whitish, fleshy larvae are about ¾ inch long when fully grown and may be recognized by their prominent black heads, the paired black spots on the three segments of the thorax, and two short, dark hooks at the posterior end of the abdomen. Larvae burrow into the woodwork of grain bins, and a seemingly clean bin may harbor thousands of larvae, pupae, and adults. The life cycle requires from 2 to 14 months, many adults living more than a year. The females lay about 1,000 eggs in protected situations, such as in cracks near food. The cadelle feeds upon grain and grain products and does much damage to bolting silk in flour mills. It is especially injurious in poorly sanitated mills.

THE LESSER GRAIN BORER, *Rhyzopertha dominica,* a brown or black slender cylindrical beetle with numerous coarse elevations on the pronotum, is about ⅛ inch long and is most common in the Gulf States but may occur anywhere in the country. Both larvae and adults attack and destroy wheat kernels. The females lay up to 500 eggs each, dropping them in the loose grain. In warm weather the life cycle is completed in about 1 month.

THE ANGOUMOIS GRAIN MOTH, *Sitotroga cerealella,* is a light grayish-brown or straw-colored moth with a satiny luster and wing expanse of ½ inch to ⅔ inch. The hind wings are fringed with long, dark setae, and have a point at the tip like a finger, which distinguishes the insect from the clothes moth. The larva is white, with a brown head. It is only ⅕ inch long and lives within the individual grain of wheat, corn, or other grain. The winter is passed in the larval stage in stored grain. The adult emerges and infests cereal crops either in the field or in storage, depositing about 40 eggs. The entire life cycle may be passed in 5 weeks. The Angoumois grain moth is second in importance to the rice and granary weevils as a pest of stored grain. It is of greatest importance in the South and in the soft-red-winter-wheat region of the Eastern and Central States.

BEETLES AND MOTHS INFESTING BROKEN GRAIN

THE CONFUSED FLOUR BEETLE, *Tribolium confusum,* and the **RED FLOUR BEETLE,** *Tribolium castaneum,* are similar in appearance and habits. Adult confused flour beetles have the antennae gradually enlarged toward the tip, whereas the antennae of the red flour beetle have the last three segments abruptly enlarged. *T. confusum* cannot fly, whereas, *T. castaneum* may fly. The elongate, reddish-brown

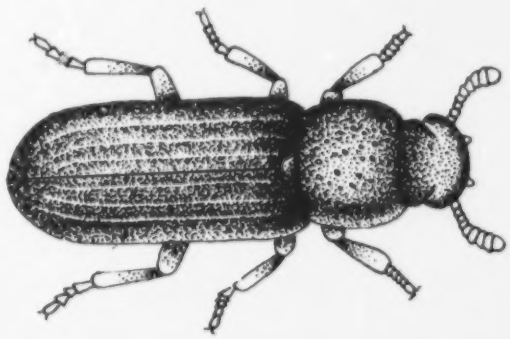

Figure 12.11 Confused Flour Beetle

beetles are about 1/7 inch long, with a distinct joint between the thorax and abdomen. The adult female may live for as long as 2 years, depositing 300 to 400 eggs. The mature larva is brownish-white with six legs, and is up to ½ inch long. The life cycle requires 2 to 4 months when temperatures are favorable. These beetles are very important pests of flour, infesting many flour mills, warehouses, and grocery stores. They also feed upon grain, beans, dried fruits, nuts, chocolate, and other foods.

THE FLAT GRAIN BEETLE, *Cryptolestes pusillus,* is one of the smallest beetles found in stored grain. It is a tiny, reddish-brown beetle about 1/16 inch long with antennae nearly as long as the insect. It is usually found with other grain pests.

THE YELLOW MEALWORM, *Tenebrio molitor,* and **THE DARK MEALWORM,** *Tenebrio obscurus,* are very similar in appearance. The adults are large beetles over ½ inch in length, the adult of *T. molitor* being dark shiny brown to black, and *T. obscurus,* a dull black. The larvae resemble wireworms and are familiar to many people as dried food for aquarium animals. Although these insects are cosmopolitan in distribution, they are rarely of major importance. In-

festation of the human intestine by larvae of the yellow mealworm has been reported (Palmer, 1946).

THE MEDITERRANEAN FLOUR MOTH, *Anagasta kuhniella,* is dark, less than 1 inch in wing expanse, with wavy black bars on the forewings and with dirty white hind wings. The whitish larva (about ½ inch long with a brown head) lives in a silken tube, and its silk clogs machinery and tangles flour, nuts, chocolate, dried fruit, and other foods.

THE INDIAN MEAL MOTH, *Plodia interpunctella,* has a wing expanse of ½ to ¾ inch, with the basal one-third of each forewing dull white to cream and the outer two-thirds, brown to copper. The females lay about 200 eggs, and the tiny whitish, brown-headed larvae emerge in 2–14 days. The life cycle is 50–305 days. Full-grown larvae (⅓ to ½ inch long) produce silk which webs together flour, graham crackers, nuts, dried fruit, powdered milk and other foods.

SPIDER BEETLES, *Ptinus* spp., are occasionally found infesting broken grain. They are quickly distinguished by their spider-like form. Although widespread, they rarely cause serious damage in the United States. *Ptinus tectus* may cause intestinal canthariasis.

BEETLES INFESTING DRIED PEAS AND BEANS

THE BEAN WEEVIL, *Acanthoscelides obtectus,* is a short, snout beetle that feeds upon stored beans and peas. The adult is ⅛ inch long with reddish legs and a light olive-brown color, mottled with darker brown and gray. The body narrows evenly toward the head. The tiny, legless larva and pupa live within the bean, whereas the adult emerges from the bean and feeds upon other materials. The female deposits eggs in beans, both in the field and in storage, and six or seven generations may be completed in a year. As many as 28 weevils have been known to develop in 1 bean. The use of tight sacks has been found to afford considerable protection. Bean vines and other refuse should be burned in the field or plowed under to prevent propagation of this insect. The adults hibernate in fields and warehouses.

THE PEA WEEVIL, *Bruchus pisorum,* appears similar to the bean weevil, but is larger (⅕ inch long), brownish flecked with white, and with black to gray patches of scales. There is one generation per year, the adults overwintering in peas in the field or in storage. Egg deposition ocurs only in the field. House mice eat pea weevils by cracking open the infested pea, eating the weevil, and discarding the pea.

BEETLES AND FLIES INFESTING MEATS AND CHEESE

THE LARDER BEETLE, *Dermestes lardarius,* is about ⅓ inch long, dark brown, with a wide yellow band across the front part of the wing cover. The larva is brown, very hairy, tapering towards the ends of the body. This insect is world-wide in distribution. The eggs are laid on or near animal products such as feathers, horns, skins, hair, ham, bacon, dried beef, and like products. The life cycle requires 40 to 50 days. This insect may be found in dog biscuits, cheese, museum specimens, dried fish, and stored tobacco. It is also known to penetrate lead. Control consists chiefly of protection from attack, such as wrapping hams in paper and cloth immediately after smoking, and the use of cold storage lockers. Skins and hides are protected by dusting or spraying with 5 percent DDT or 1 percent lindane.

THE RED-LEGGED HAM BEETLE, *Necrobia rufipes,* a shiny blue to green beetle 1/7 to ¼ inch long with reddish legs, is especially troublesome in the Middle Atlantic States. The adults usually disperse by rapid running, but are able to fly. The mature larva is about ⅔ inch long, purplish, with six short legs, and tapers toward the head. The life cycle usually occupies 36 to 150 days. The female lays 400 to 1,000 eggs on exposed meat, indicating the need for prompt wrapping of hams immediately after smoking. The larva is able to perforate grease-soaked paper wrappings. This pest lives primarily on dead and decaying animal matter, but is sometimes reported in groceries and warehouses in smoked ham, bacon, garlic, bone meal, and other materials.

THE CHEESE MAGGOT or **CHEESE SKIPPER,** *Piophila casei,* is a fly about the size of the house fly. The adult is black with bronze tints on the thorax, reddish-brown eyes, and iridescent wings which lie flat over the body. The larva is a slender maggot, pointed toward the head end. The larva is able to skip as much as 10 inches horizontally and 6 inches vertically, by curving its body into a ring, fastening its mouth hooks onto the end of the abdomen, suddenly releasing its hold, and throwing itself into the air. The life cycle of the insect is completed in 12 days under favorable conditions. The adult deposits 140 to 500 eggs over a period of 3 to 4 days. This insect infests ham and cheeses. The adults can transmit enteric

diseases to man by contamination, and the maggots cause intestinal irritation when ingested with cheese. Infestations of the cheese maggot should be prevented by screening (30-mesh) storage rooms and wrapping meat in paper and enclosing it in a tight cloth sack. Cheese may be protected with cheesecloth and paraffin. The recognized common name "cheese skipper" is very unfortunate for this pest, because "skippers" are moth-like Lepidoptera.

BEETLES THAT ARE GENERAL FEEDERS ON STORED FOOD

THE SAW-TOOTHED GRAIN BEETLE, *Oryzaephilus surinamensis*, is an important pest known throughout most of the world. A closely related species, *Oryzaephilus mercator*, is also important and is often mistaken for the saw-toothed grain beetle. The adult is a small, active, brown beetle $^1/_{10}$ inch long, with a flattened body and six saw-toothed projections on each side of the thorax. The larva is yellowish-white, less than $^1/_8$ inch long, with a brown head, and abdomen tapering toward the tip. The females live for 6 to 10 months, depositing 45 to 285 eggs in foodstuff. Several generations may occur each year, as the life cycle requires only 3 to 4 weeks during the summer. The saw-toothed grain beetle is an important pest in grocery stores, food warehouses, and grain storage. It readily penetrates packaged cereals, dried fruits, and candies. It also attacks flour, meal, sugar, drugs, dried meat, and tobacco.

THE CIGARETTE BEETLE, *Lasioderma serricorne*, is primarily a pest of tobacco, but will feed upon many other products as was evidenced by its presence in the tomb of Tutankamen in Egypt. This small, oval, light brown beetle is $^1/_{10}$ inch long with smooth wing covers. The head is retracted beneath the thorax. The adult beetle flies readily. The larva is yellowish-white, curved, very hairy, with a light brown head, and about $^1/_6$ inch in length. The life cycle requires from 6 to 12 weeks, and there may be five to six overlapping generations per year in warm localities, but only one generation in cooler areas. The female deposits as many as 100 eggs in tobacco, grain, milled cereals, and other products. This insect infests upholstered furniture, feeds, dried plants, drugs, black and red pepper, pyrethrum powder, raisins, rice, and many other commodities.

THE DRUG STORE BEETLE, *Stegobium paniceum*, is similar to the cigarette beetle in appearance, but is slightly larger, more elongate, and has the wing covers distinctly striated. It has the last three segments of the antennae saw-like and ranges from $^1/_{10}$ inch to $^1/_8$ inch in length. Its food is even more varied than that of the cigarette beetle, and it is said to feed "upon almost anything except cast iron." Its peculiar diet includes such odd materials as strychnine, belladonna, books, mummies, and lead.

THE BLACK CARPET BEETLE, *Attagenus piceus*, the most destructive carpet beetle in the United States, is distributed throughout the country. The adult is a small, black, or dark brown beetle not over $^3/_{16}$ inch in length, sometimes flecked with white or reddish scales. The adults feed on the pollen of flowers. The life cycle varies from 1 to 2 years, and only the larval stage attacks stored products. The larva is long (about $^3/_8$ inch) and narrow with golden setae on the body, and a tuft of long setae at the posterior end. When disturbed, it curls up and "plays possum." Larvae feed upon seeds, grain, woolens, silks, felts, skins, feathers, milk powder, and many other materials. They are often abundant under undisturbed portions of carpets (such as under sofas and large chairs) and in dark corners. The damage may not be noticed until a heavy infestation has developed. Its larvae may cause cantheriasis.

THE KHAPRA BEETLE, *Trogoderma granarium*, is a pale red to brown or black beetle about $^1/_{11}$ to $^1/_8$ inch long. Females are much larger than males. The female lays up to 126 eggs which hatch yellowish-brown larvae with long setae. The larva develops into a pupa and the pupa into an adult. The life cycle requires about 6 weeks during warm weather. The larvae may live for years without food. Khapra beetles feed on dried vegetables or animal matter of all kinds. Only the southwestern United States is known to be infested at the present time.

ANTS, BEES, WASPS, HORNETS, AND YELLOW JACKETS

Class Insecta, Order Hymenoptera

Ants are among the most abundant of animals being found under both arid and humid conditions in the tropical, temperate, and upper temperate regions of the world. They feed upon every food consumed by man and are troublesome household pests. Some ants feed predominately on sweets, whereas others prefer meats and grease. Ants may be rare vectors of the organisms causing enteric diseases from feces or garbage to human food. All ants bite, and some ants sting. Reaction to

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ant bite or ant sting can be severe in sensitive individuals. Fire ants, which have a highly venomous sting, are a major problem in parts of the southeastern United States (Agricultural Research Service, 1957). Ants act as scavengers and predators of many harmful insects.

Ants are distinguished from other insects by having the first one or two abdominal segments reduced into a knobbed pedicel or stalk situated between the thorax and the abdomen proper, and by their elbowed antennae. Termites have a broad connection between the thorax and abdomen, and straight bead-like antennae. The forewings of ants are larger than the hind wings and have comparatively few veins, whereas the two pairs of wings of termites are similar in size and appearance and have many veins. Ants have chewing mouthparts, their heavy mandibles being suitable for biting, piercing, cutting, and gnawing. The smallest ant is less than $\frac{1}{16}$ inch long, and the largest ant attains a length up to $1\frac{1}{2}$ inches. They are among the most abundant of living creatures infesting the home. Ant colonies may last many years, some of them longer than the 3 score and 10 years allotted to man. The colony is established when the newly mated female discards her wings, digs a nest, and produces eggs for a new brood. After nourishing her young through the larval stage, her labors are over as the larvae pupate and the young workers emerge and take over the work. The worker ants feed the queen, fight off all enemies, construct a maze of tunnels, and care for the young. When the colony has become strong, a special brood of males and females is reared to establish new colonies. These winged adults emerge for their marital flight in vast numbers in order to mate and seek new harborage.

THE ARGENTINE ANT, *Iridomyrmex humilis*, is a common household pest throughout the Southern States and in some Northern States where hordes of these pest invade the home in search of sweets. The nests may be found in open ground, or underneath wooden objects, out of doors, or may occur in the home. Iridomyrmecin, an insecticide originally isolated from this ant, has recently been synthesized (Time, 1 June 1959, p. 58).

THE IMPORTED FIRE ANT, *Solenopsis saevissima* var. *richteri*, through its foraging and mound building, is destructive to many agricultural crops and injures young livestock and wildlife in some instances. Its bite and sting are vicious, producing a marked dermatitis and general toxic effect. Its venom is also insecticidal and antibacterial, producing instantaneous paralysis in fruit flies, house flies, termites, weevils, and mites. It is effective against *Streptobacillus casei* bacteria (Science, 128:306–7, 1958). The imported fire ant is believed to have been introduced into Alabama, prior to 1920, but was not reported until 1930. It now occurs in nine Southern States with heaviest infestations in Alabama, Mississippi, Louisiana, and Florida (Agricultural Research Service, 1957).

Figure 12.12 Imported Fire Ant

THE SOUTHERN FIRE ANT, *Solenopsis xyloni*, and related species are highly prevalent in the southern United States. The stings of this ant are of great importance to citrus grove operators as the ants must be controlled before the fruit may be picked when heavy infestations occur. This ant feeds upon meats, greases, and other fatty foods, and often gnaws fabrics, especially soiled clothes.

THE TROPICAL FIRE ANT, *Solenopsis geminata*, nests in exposed places out of doors and under houses, and the average nest occupies 2 to 4 square feet. Fire ants often cause injury to nursery stock and have the habit of carrying away seeds.

THE THIEF ANT, *Solenopsis molesta*, nests in walls, and may be highly prevalent around sinks and cupboards. It feeds chiefly upon greasy materials but may feed on sweetened foods.

THE PHARAOH ANT, *Monomorium pharaonis*, feeds on sweets and fatty foods. It is one of the most difficult species to control in the home as many colonies may exist in a single residence.

THE PAVEMENT ANT, *Tetramorium caespitum*, is one of the commonest species invading the home where it is found throughout the year, especially during the summer months. It is annoying because of its propensity for getting into everything in the house from food to shoe polish (Lange, 1961).

THE CORNFIELD ANT, *Lasius alienus americanus*, is an important household pest in the Northern States. This species enters the home for sweets and is one of the commonest ants out of doors. The mounds of its nest are common on lawns and in fields and may occur in cracks in pavement around the home.

THE CRAZY ANT, *Paratrechina longicornis,* is so called because it runs aimlessly about. It feeds upon animal matter, sweets, and kitchen scraps. It has been reported attacking fleas in Puerto Rico (Fox and Garcia-Moll, 1961).

THE ODOROUS HOUSE ANT, *Tapinoma sessile,* is widely distributed throughout the United States, and is especially apt to invade the home during rainy weather. It has an unpleasant odor on being crushed. The nesting site must be discovered in order to effect control. The nest may be in the woodwork of the house or under the subfloor near hot water pipes.

CARPENTER ANTS are very large. The black carpenter ant, *Camponotus herculeanus pennsylvanicus,* and its related subspecies are widely distributed throughout the Eastern States. More than one queen may be present in a colony. Structural damage to a home may be extensive enough to require major repairs, although these ants usually excavate wood that is decayed or damaged by other organisms (Scott, 1958).

BEES, WASPS, HORNETS, YELLOW JACKETS, and other stinging Hymenoptera possess venom and can cause severe illness and death in man. Honey bees are second to rattlesnakes in producing death by venom in the United States (see page 1). In a 10-year period, 138 deaths from snake bite were reported of which 94 were due to rattlesnakes. During the same period, 124 deaths were recorded due to allergic or anaphylactic (shock) reactions to bee sting. Hornets, wasps, and yellow jackets accounted for 101 other deaths. Bees are usually beneficial; but, when they are in a position to attack man or have become colonized in the hollow walls of a home, it may be desirable to control them. A 5 percent chlordane dust applied liberally to the openings by means of a hand garden duster will generally provide control although it may require more than one treatment to destroy the colony. Close the opening in order to prevent recurrence of the infestation. Should the colony be well established, remove the dead bees, combs, and honey in order to prevent an influx of scavengers such as carpet beetles, ants, and cockroaches. Although bees may be controlled with calcium cyanide, this dangerous fumigant must not be used by persons unfamiliar with the necessary precautions. Carpenter bees are large attractive specimens with metallic sheen that burrow into the timbers of the home and may cause extensive damage. They are controlled with DDT, lindane, or dieldrin. Wasps', hornets', and yellow jackets' nests are treated with the same materials used for bee control. Applications are made early in the morning when there is little activity in order to avoid wasp stings and to kill the maximum number. Whereas bee colonies exist for many years, a yellow jacket or hornet colony will last for just 1 year with the young fertilized queens surviving to start new colonies during spring.

Figure 12.13 Paper Wasp

HOUSEHOLD AND STORED-FOOD SPECIES OF LESSER IMPORTANCE

SLUGS AND SNAILS (Phylum Mollusca, Class Gastropoda, Order Pulmonata) are occasionally found in basements and rarely enter the home in large numbers. These molluscs are often found underneath boards, flower pots, and stones in moist places during the daytime. Slugs and snails are controlled outdoors by the distribution of 1 percent metaldehyde or 6 percent arsenic baits sold in garden, drug, or department stores. Table salt "barriers" may also be used; but, since table salt is toxic to plants, care must be taken in its use that it does not reach ornamental plants.

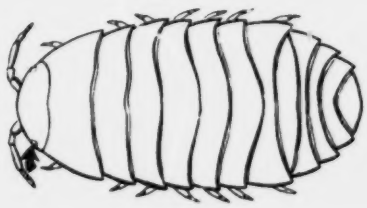
Figure 12.14

Slug

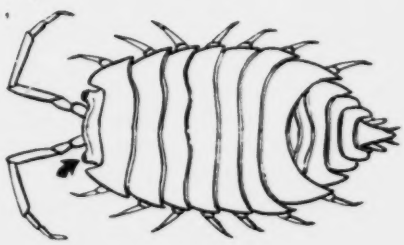
Snail

SOWBUGS AND PILLBUGS (Class Crustacea, Order Isopoda, Family Armadillididae) are world-wide in distribution and may attack and kill seeds or young plants. They are abundant in moist locations and are found in large numbers under boards and vegetable debris. They may invade homes in considerable numbers. Sowbugs cannot roll up into a ball like the pillbug and have two prominent tail-like appendages that the pillbug does not have. Removal of boards, paper, cardboard, vegetable debris, and other refuse from the yard will greatly reduce the number of sowbugs and pillbugs. They may also be controlled by dusting the moist ground with 5 percent DDT or 3 percent benzene hexachloride dust.

Figure 12.15



Pillbug



Sowbug

CENTIPEDES (Class Chilopoda) or "hundred leggers" are fast-moving elongate arthropods having one pair of legs for each body segment. The mouthparts are essentially the same as insect mouthparts of the chewing type. The venomous *fangs* are *modified legs of the first body segment*. The reproductive organs open posteriorly. Centipedes are predaceous and feed mainly on soil insects. About 150 species are known from the United States. Many are capable of inflicting venomous bites on man, but death from centipede bites rarely occurs. In all cases of centipede bite, however, the wound should be disinfected; and a physician should be consulted. Some species attain a length of 6 to 8 inches, particularly species of *Scolopendra* in the western half of the United States. They are greatly feared. A few species of centipedes have been recorded infesting human nasal, intestinal, and urinary cavities. One species, the eastern house centipede (*Scutigera cleoptrata*), invades homes, particularly damp base-

Figure 12.16 Centipede

ments, rather commonly. Centipedes may be controlled by 1 percent lindane, or 2 to 5 percent malathion emulsion in a spot application as for cockroaches (Minton, 1959, part 3).

MILLIPEDES (Class Diplopoda) or "thousand leggers" are slow-moving, elongate arthropods having two pairs of legs for each body segment. They are sometimes mistaken for centipedes which they resemble superficially but to which they are only distantly related. Millipedes live in leaf mold, rotten logs, and other humid places. About 750 species are known from the United States. Some feed on living plants and are agricultural pests. Species of *Julus* and *Polydesmus* have been reported from the digestive and urinary tracts of man while *Julus* spp. and *Fontanaria virginiensis* are intermediate hosts for the rat tapeworm. In addition, many species exude a vesicating (blistering) venom and may cause injury to persons handling them. Some (*Rhinocricus* spp.) are capable of squirting venom some distance and may cause severe injury to the eyes as well as the skin. In recent years numerous complaints have been received of millipedes invading base-

Figure 12.17 Millipede

ments, terrace apartments, and ranch type houses built on concrete slabs; or climbing the sides of houses after dark. Two percent chlordane emulsions, 5 percent chlordane dust, and 2–5 percent malathion dusts have been reported to give good control. Since millipedes are most comonly found in damp situations, another effective control measure has been the removal of mulch or low vegetation from the immediate surroundings of a house (Chamberlin and Hoffman, 1958).

SPIDERS (Class Arachnida, Order Araneida) are venomous arachnids common throughout the world. Most feed on other arthropods, and are generally beneficial to man. Some occur in houses and spin webs to trap insects on which they feed. These webs collect dust and debris to form "cobwebs." Although all spiders possess venom, few are dangerous to man. Some large species are greatly feared, but among species in the United States, only the black widow spider (*Latrodectus mactans*) and the brown spider (*Loxosceles reclusa*) inject sufficient venom to cause death. The black widow is an ebony spider, usually with a red or orange hourglass on the underside of the abdomen. The brown spider, an inconspicuous species, has a fiddle shaped marking on the cephalothorax and only six eyes. The bite of *Loxosceles reclusa* causes severe itching, and production of a thick wheal. This wheal may later turn reddish or purplish, finally resulting in

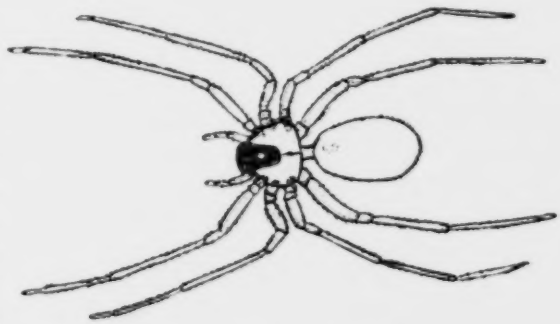


Figure 12.18 Brown Spider

a blackish necrotic area which sloughs off leaving a deep, sharply-defined granular area surrounded by healthy tissue (Atkins, *et al.*, 1958). This is similar to "gangrenous spot" of Chile and other South American countries caused by *Loxosceles laeta*. Since individuals differ greatly in their reaction to arthropod venoms, *all spider bites should be considered serious; and a physician should be consulted immediately*. Secondary bacterial infection is common; consequently all spider bites should be disinfected at once. Periodical eradication of spiders and their egg masses by mechanical means is a satisfactory method of control. Use a broom to sweep away and crush spiders, egg masses, and webs. Residual spraying with 1 percent lindane, 2 percent chlordane, or 0.5 percent DDVP is recommended. Because of the frequency and severity of black widow spider bites in outdoor privies, a periodic inspection of these structures should be made, and the undersides of the seats painted with creosote, crude oil, insect repellent, lindane, chlordane, or ronnel (Minton, 1959, part 4).

SCORPIONS (Class Arachnida, Order Scorpionida) are found in much of the continental United States, being most common in Arizona, California, Nevada, Utah, New Mexico, and Texas. They are rare north of a line drawn between Baltimore, St. Louis, Salt Lake City, and San Francisco. Scorpions are most active at night. A general classification is **BARK SCORPIONS** (the deadly genus *Centruroides*), vs. **GROUND SCORPIONS** (most other United States species). *Centruroides* spp. are often found under loose bark and in crevices between the bases of palm

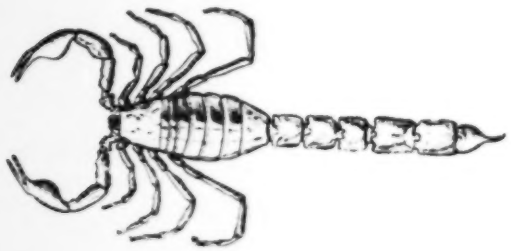
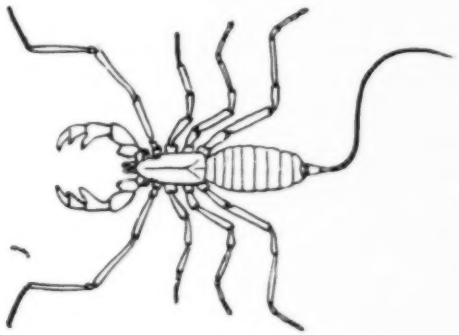


Figure 12.19 Scorpion

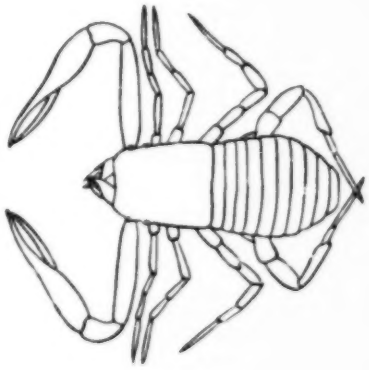
tree leaves. They never burrow but may hide under boards, rubbish, bricks, etc., which provide both shelter and soft-bodied insects and spiders upon which they feed. The places commonly occupied by scorpions in a home are under the house and in the attic. They enter attics usually by climbing between wall partitions. They may be found in washrooms, kitchens, or bathrooms where water is available and in daytime may hide in closets, shoes, folded blankets, etc. Ground scorpions frequently bury in loose gravel without food or water for as long as 6 months. Scorpions rarely sting man and then only when provoked. Few species are deadly. They are, however, common, and *all scorpion stings should be considered dangerous.* To control scorpions, remove old boards, cardboards, loose rocks, old mattresses, and other debris from near occupied buildings. Ducks and chickens will quickly eliminate most scorpions from an area. Apply 2 percent chlordane emulsion or 5 percent chlordane dust where the scorpions hide (Minton, 1959, part 1).

WHIP SCORPIONS (Class Arachnida, Order Pedipalpida, Family Thelyphonidae) resemble true scorpions in many respects, but their "tail" is extremely slender, almost hair-like, and has no terminal stinger. They are sometimes called vinegarones (vinegar roans), due to the acetic odor they emit. Whip scorpions can pinch severely with their claws, but are not otherwise of public health importance. They are generally beneficial. One species (*Mastigoproctus giganteus*) is recorded from the southern United States. These fearsome looking animals, which attain a length of several inches, are sometimes found in and under houses (Minton, 1959, part 1).

Figure 12.20



Whip Scorpion



Pseudoscorpion

PSEUDOSCORPIONS (Class Arachnida, Order Pseudoscorpionida) are minute (less than one-quarter inch) soil arachnids which resemble scorpions in general appearance, although they do not have the long "tail" and possess no stinger. They are not known to be of public health importance. Pseudoscorpions are found in dusty places in houses, as in basements or among undusted books in the library.

DADDY-LONG-LEG SPIDERS (Class Arachnida, Order Phlangida) are notable for their very long legs which are more than five times as long as the body. They differ from true spiders in that their abdomens are clearly segmented and that they do not

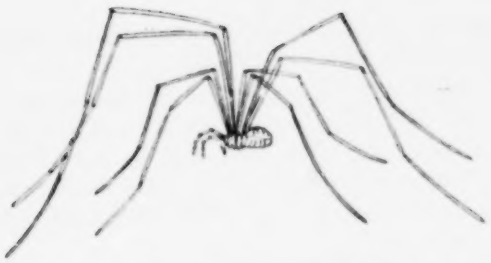


Figure 12.21 Daddy-Long-Leg Spider

spin webs. They are not known to be of public health importance and are generally beneficial to man. If control is desired, use 1 percent lindane emulsion.

TICKS (Class Arachnida; Order Acarina; Families Argasidae, soft ticks; and Ixodidae, hard ticks) suck blood and may transmit Rocky Mountain spotted fever, tularemia, relapsing fever, and other diseases. Toxic secretions of hard ticks can cause tick paralysis. Hard ticks live on or near vegetation; soft ticks, in or near the nest of the host. Both ticks may infest houses.

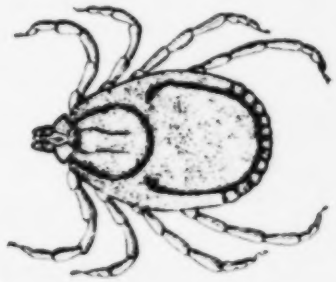


Figure 12.22 Hard tick

Clearing vegetation from an area will usually eliminate most ticks. Cracks and chinks which might be occupied by soft ticks should be filled. When in tick-infested areas, wear impregnated (with 12 percent benzyl benzoate) protective clothing. Tuck trousers into boots and shirt into trousers. Check every 2 hours for attached ticks. Mosquito repellents will help. Treat infested areas with 10 percent DDT dust, 5 percent DDT sprays, 5 percent chlordane dust, or 2 percent chlordane sprays. Pay particular attention to 4-foot swaths along walkways and roadsides. Use 1–4 percent malathion dust on dogs, 1 percent rotenone dust on cats. Use 0.5 percent lindane, 0.5 percent dieldrin, or 0.5 percent diazinon emulsion in kennels or houses, applied as a spot spray where ticks are harboring.

MITES (Class Arachnida, Order Acarina, many Families) are minute, eight-legged, and soft bodied. The larva (first stage after egg) possesses only six legs (Hughes, 1961; Salmond, 1956). When in mite- ("Chigger-") infested country, wear impregnated (with 12 percent benzyl benzoate) clothing with the trousers tucked in the boots and shirt tucked into trousers. For rodent, bird and bat mite control, keep animal nests away from buildings. Keep food and harborage cleaned up. Rodent-, bird-, and bat-proofing may produce the best results. "Chiggers" and other field mites may be controlled by application of 1 percent dieldrin, 2 percent chlordane, 5 percent ovex (ovotran), or 2 percent malathion spray, or 2 percent dimite dust to the infested ground at a rate of about 1 pound technical grade insecticide per acre. Clover mites do not bite but may be present in tremendous numbers. They may be similarly controlled (MacCreary and Connell, 1961).

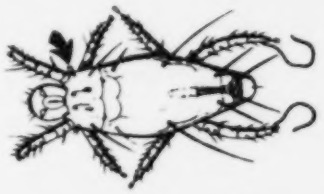


Figure 12.23 Straw-itch Mite

THE CHEESE MITE, *Tyrophagus castellani*, occurs on cheese and may attack dried meat, fruit, and flour. Its bite causes "copra itch," an intense dermatitis associated with copra workers. When swallowed with food, it causes intestinal irritation and diarrhea.

THE GRAIN MITE, *Acarus siro*, lives on flour, cheese, dried fruit, and similar stored foods. Its bite causes "vanillism," an intense dermatitis in those who handle vanilla pods. It is very injurious to grain or flour containing over 13 percent moisture. Proper ventilation of stored items plus sanitation will usually control infestations. Flour may become very heavily infested; and, in some cases, the entire mass may appear to be in motion. When swallowed with food, the numerous spines of the ham mite irritate intestinal tissues and cause diarrhea. The life cycle of *Acarus* mites can be completed in about 2 weeks although it is greatly prolonged in cold weather.

THE SUGAR MITE, *Glycyphagus domesticus*, usually associated with sugar but occasionally infesting other stored foods, causes a skin inflammation known as "grocer's itch" or "baker's itch."

THE STRAW ITCH MITE, *Pyemotes ventricosus*, is predaceous and does not attack stored food. It feeds on insect larvae which infest food and wood and is, therefore, common in warehouses. It will attack and bite man producing a "grain itch" or "straw itch" (Fine and Scott, 1963).

THE FLORICOLUS GRAIN MITE, *Tarsonemus floricolus*, is another predaceous mite sometimes found around stored food. When swallowed, it causes intestinal irritation and diarrhea.

SILVERFISH AND FIREBRATS (Class Insecta, Order Thysanura, Family Lepismatidae) are fast-moving, wingless insects with long antennae. They are glistening silver, brown, or black, and are readily distinguished by their three long terminal tails. They are common around homes and restaurants where they feed primarily on carbohydrates; starched cloth, book bindings, wallpaper paste, and stored grains. They exhibit little metamorphosis, the young looking very

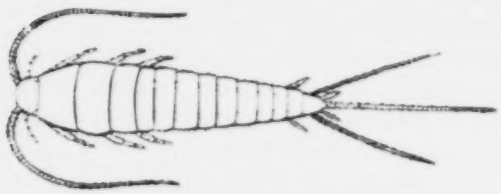


Figure 12.24 Silverfish

much like the adults. Development of the common silverfish (*Lepisma saccharina*) requires about 12 weeks from egg to adult. Silverfish range far from their hiding places at night in search of food, and will quickly infest an entire building. They harbour where food and moisture can be readily obtained. Firebrats harbour under hot, dry conditions such as behind stoves or around fireplaces. In spite of their prevalence and constant close association with man, silverfish and firebrats do not appear to be the vectors of any human disease. However, very little research has been done in this regard. Silverfish and firebrat control may be accomplished by applying 5 percent DDT or 1 percent lindane emulsion to cracks and crevices and behind furniture. Special attention should be given to the basement, attic, closets, and around bookcases. A good cockroach control treatment with 2.5 percent chlordane, 3 percent malathion, or 0.5 percent diazinon emulsion will usually eliminate silverfish and firebrats also (Mallis, 1960, pp. 120–138).

SPRINGTAILS (Class Insecta, Order Collembola) may invade the kitchen and bathroom in very large numbers. They breed in moist places such as damp basements and drains, and correction of these deficiencies may eliminate the problem. Infestations often

Figure 12.25 Springtail

arise in the soil of potted plants kept in the home. Springtails derive their name from the fact that a spring situated beneath the body can be released by the insect, causing it to jump into the air. These insects feed, for the most part, on algae and fungi, and on decaying vegetable matter. Springtails are controlled by application of 5 percent DDT, 1 percent lindane or 2 percent chlordane emulsion, 5 percent chlordane dust, or by the use of pyrethrum sprays and dusts.

EARWIGS (Class Insecta, Order Dermaptera) are short-winged, brown insects with a pair of forceps at the end of the abdomen. In the female, the forceps are fairly straightsided, whereas the male forceps are bowed outward. Some individuals believe that the earwig can enter the ear and bore down into the brain, but the insects are harmless. Earwigs do not become

Figure 12.26 Earwig

important to man until they occur in tremendous numbers. Literally thousands of them may invade a house or motel and make it untenable to human occupants. Experiments show that the European earwig (*Forficula auricularia*) is able to transmit gram negative coli bacilli and *Bacillus lactis aerogenes* by means of simple

contact. Inoculation of agar with earwig feces yielded, nearly exclusively, mucus-encapsulated *B. l. aerogenes.* Eichler (1956) regards mass appearances of earwigs constitute an enteritis menace at least as great as house flies. Earwigs may be controlled by application of 10 percent DDT or 5 percent chlordane dust outdoors or 5 percent DDT emulsion indoors.

TERMITES (Class Insecta, Order Isoptera) are a key factor in the deterioration of housing in many parts of the United States as well as elsewhere in the world. Housing quality, one of the basic factors in public health, is often used as a general index of community health. For these reasons, public health workers should have a general knowledge of these pests. About 60 species of termites have been reported from the United

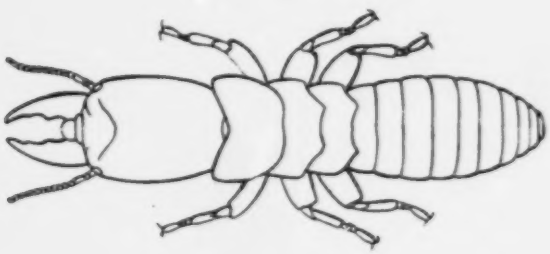


Figure 12.27 Termite

States. These may be grouped into three types based upon the type of damage they do: (1) *wet wood termites* damage living trees and are of relatively minor importance in most areas; (2) *dry wood termites* establish colonies in cured wood and, while rare, may be a problem in museums and storage warehouses; (3) *subterranean termites* attack wood from colonies established in the soil and are the ones of the greatest economic importance. Control of wet wood termites involves tree surgery, proper treatment of pruning scars, careful timing of fertilizer applications, root fumigation with carbon bisulfied or carbon tetrachloride, and soil poisoning with 1 percent chlordane or 0.3 percent dieldrin emulsion. Control of dry wood termites involves impregnation of wood with 5 percent pentachlorophenol solution (Snyder, 1954) or fumigation. Subterranean termites live in a subsoil colony containing: *workers* which are the most common and do the wood damage; *soldiers* which guard the colony; a *queen* who is the mother of all individuals in the colony; and *reproductives* who swarm from *the colony* each year to found new colonies. Subterranean termites are very sensitive to moisture conditions; and, although they may feed on wood, they must leave it and return to the soil every few hours for moisture. Ordinarily they attack only wood in contact with the soil, but they can build cellulose tunnels through which they can climb to attack wood above ground level. It is often difficult to assess the extent of termite damage or to ascertain that complete control has been achieved. Control usually involves (1) *environmental techniques* such as keeping the yard clear of scrap wood, keeping structural wood off the ground, and use of termite shields; (2) *wood impregnation* with some toxic chemical such as pentachlorophenol; and (3) *soil poisoning* with 1 percent chlordane or 1 percent dieldrin emulsions (Ebeling and Pence, 1958).

PSOCIDS OR BOOK LICE (Class Insecta, Order Psocoptera) are annoying because of their habit of crawling over everything in the home. Most of the damage attributed to these insects may actually be caused by silverfish or cockroaches. Psocids go through three stages in their development; the egg,

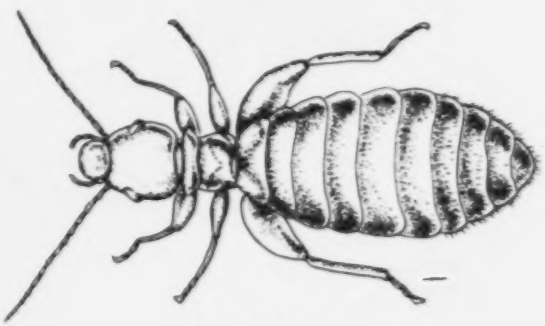


Figure 12.28 Psocid

nymph, and adult. These tiny pale insects are often observed in old books or in cornmeal. They feed for the most part on microscopic molds and are most abundant on starchy materials in moist situations. Although most psocids live out-of-doors, they may occasionally enter the home in large numbers. Psocids are controlled to some extent by spraying with 1 percent lindane, or 2 percent chlordane in an oil base spray. These insects may be controlled in closets by the use of para-dichlorobenzene suspended from the ceiling in cheesecloth bags. One pound of insecticide should be used for each 100 cubic feet of enclosed area, and the door closed during the treatment.

CRICKETS (Class Insecta, Order Orthoptera, Families Gryllidae and Gryllacrididae) have biting mouthparts, long legs fitted for jumping, and may have wings when full grown. They develop by gradual

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metamorphosis, going from the egg through a series of nymphal instars to the adult. The adult male produces the familiar chirping sound by scraping his upper wings together. **THE HOUSE CRICKET,** *Acheta domestica,* is found throughout the United States. This shiny, black insect is fond of warmth and often becomes troublesome in bakeries and homes. In warm weather, it lives out-of-doors, especially in garbage dumps, and enters the home chiefly in cold weather. They may be numerous in newly constructed homes. **CAVE AND CAMEL CRICKETS** occur throughout the world. They are usually wingless and have antennae that may be four or five times as long as the body. These large nocturnal insects are usually brown or gray in color and may be found in out-buildings or basements. They apparently do little, if any damage. **NINAS DE LA TIERRA** or **JERUSALEM CRICKETS** (*Stenopelmatus fuscus*) are large clumsy insects with big heads. Many people in the southwestern United States believe they have a venomous bite, but they are harmless. Crickets may be controlled by applications of 2 percent chlordane emulsion in and around the fireplace, in dark crevices, in basements, and behind baseboards. The cricket problem in a community may be reduced greatly by converting the insanitary refuse dump into a sanitary landfill or employing efficient incineration (Mallis, 1960).

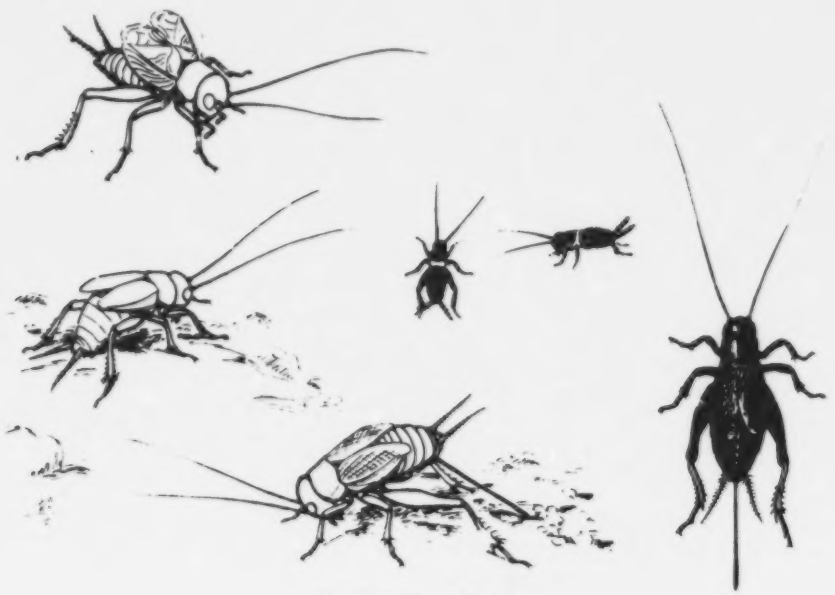


Figure 12.29 Crickets

BOXELDER BUGS (Class Insecta, Order Hemiptera, Family Coreidae), *Leptocoris trivittatus,* are pests of box elder and other trees, doing them little damage but creating a considerable nuisance in the home. They enter buildings during the late summer, and may bite man. Control can be effected by spraying the massed insects on trees and on the sides of buildings. Five percent chlordane or 0.5 percent dieldrin emulsion or suspension gives satisfactory control. Control has been achieved with 0.32 percent lindane spray and 0.025 percent pyrethrins–0.24 percent piperonyl butoxide sprays. Five percent DDT solution may be used inside of structures for residual effect.

FLIES (Class Insecta, Order Diptera, many Families) are pests. They transmit diarrhea, dysentery, typhoid, cholera, intestinal worms, eye infections, yaws, anthrax, tularemia, African sleeping sickness, leishmaniasis, blinding filariasis, African eye worm, oroya fever, sandfly fever, and other diseases. Fly larvae may infest human flesh. The cheese maggot (a fly larva) is discussed on page 12. Domestic flies may be controlled by *environmental sanitation* (wrap drained garbage and store in durable cans with tight lids. Collect twice weekly using covered trucks; dispose of refuse in sanitary landfills or efficient incinerators; require removal of privies and animal shelters from city

limits by city ordinances), *physical methods* (screens, fans), and *chemical methods* (5 percent premium grade malathion emulsion indoors; 5 percent malathion plus sugar outside for control of adults; poison baits containing malathion, dipterex or diazinon where adult

Figure 12.30 House Fly

flies congregate; space spray indoors with pyrethrum or allethrin; space spray outdoors with 5 percent DDT, 1 percent lindane, 3 percent BHC or 2–5 percent malathion).

FLEAS (Class Insecta, Order Siphonaptera) suck blood and may transmit murine typhus, plague, and tapeworms to man. They may be controlled by vacuum cleaning of infested floors and rugs; dusting of infested animals (except cats), houses, and yards with 5 percent

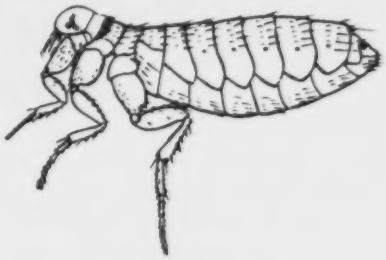


Figure 12.31 Flea

DDT or 3 percent malathion, or spraying with 1–4 percent malathion emulsion. Cats may be dusted with 1 percent pyrethrum, 3 percent malathion, 1 percent rotenone, or 0.5 percent allethrin (U.S. Public Health Service, 1963).

IDENTIFICATION OF COMMON HOUSEHOLD AND STORED-FOOD PESTS

Accurate identification of household and stored-food pests is essential to their efficient control. The keys on the following pages can be used to determine the pests involved in the vast majority of infestations. An extensive key to stored food beetles is found in Pratt and Scott, 1962.

Couplet (dichotomous) keys (such as on page 28) are typical of identification keys found in reference works and scientific papers. There are couplets of statements numbered on the left margin. Starting with couplet 1 there are in each case two descriptive statements only one of which will apply to the specimen being identified. The number at the right following the correct statement refers to the next couplet to be considered, which will again offer two choices. This method is continued until the correct identification has been made.

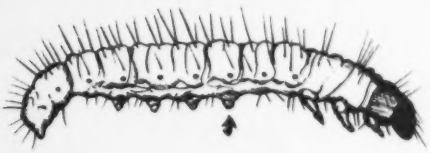
Pictorial keys (such as on page 25) are simply diagrammatic couplet keys. After making the first choice offered, follow the black lines below the picture until the correct identification has been made.

PICTORIAL KEY TO COMMON GROUPS OF HOUSEHOLD AND STORED-FOOD PESTS

LARVAL STAGES

Chester J. Stojanovich & Harold George Scott

abdominal legs present



abdominal legs absent

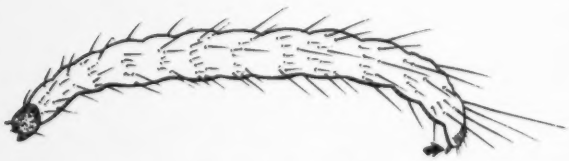
MOTH LARVAE

thoracic legs present

thoracic legs absent

BEETLE, BORER & MEALWORM LARVAE

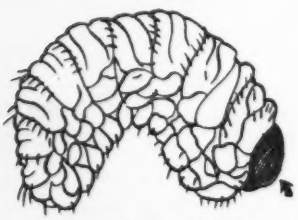
with fleshy lobes at ends of body



without fleshy lobes at ends of body

FLEA LARVAE

head capsule present



head capsule absent

WEEVIL LARVAE

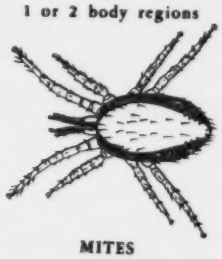
MUSCOID FLY LARVAE

KEY TO COMMON GROUPS OF HOUSEHOLD AND STORED-FOOD PESTS

ADULT STAGES

Harold George Scott & Chester J. Stojanovich

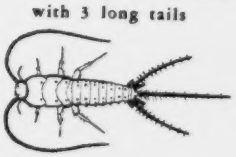
1 or 2 body regions — 3 body regions



MITES

wings well developed — wings reduced or absent

with 3 long tails — without 3 long tails



SILVERFISH

front wings shell-like — front wings not shell-like

BEETLES—WEEVILS—BORERS—MEALWORMS

antenna 4-7 segmented — antenna more than 7 segmented

SPRINGTAILS

1 pair wings — 2 pair wings

tarsus 4-5 segmented — tarsus 1-3 segmented

PSOCIDS

FLIES

wings with scales — wings without scales

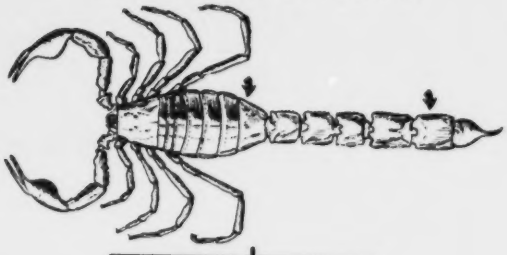
with narrow waist — without waist

MOTHS — **COCKROACHES** — **ANTS** — **COCKROACHES**

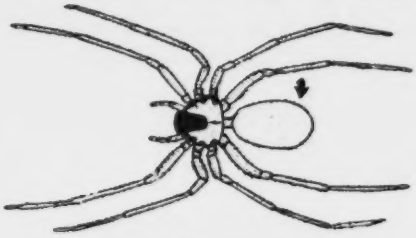
PICTORIAL KEY TO COMMON ORDERS OF ARACHNIDA OF PUBLIC HEALTH IMPORTANCE

Harold George Scott & Chester J. Stojanovich

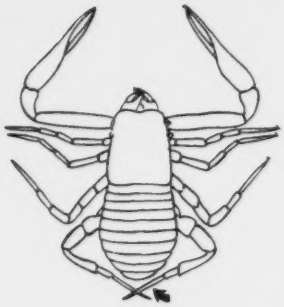
ABDOMEN DISTINCTLY SEGMENTED



ABDOMEN NOT DISTINCTLY SEGMENTED

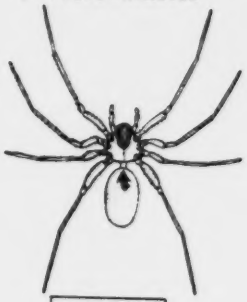


WITHOUT TAIL



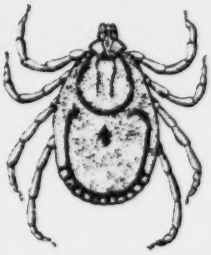
WITH TAIL

THREAD-WAISTED



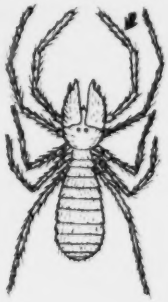
ARANEIDA
Spiders

THICK-WAISTED

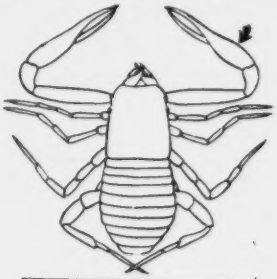


ACARINA
Ticks and Mites

PALPS WITHOUT PINCERS



PALPS WITH PINCERS

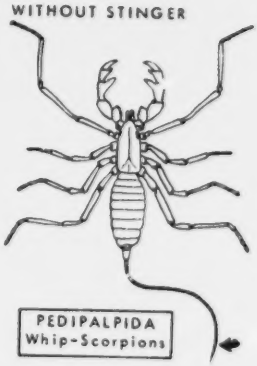


PSEUDOSCORPIONIDA
Pseudoscorpions

WITH STINGER

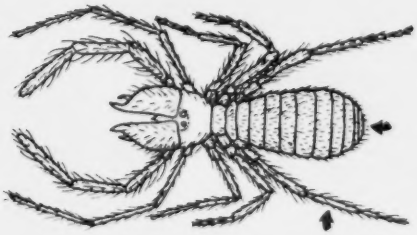
SCORPIONIDA
Scorpions

WITHOUT STINGER



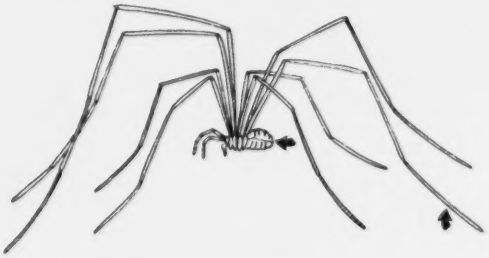
PEDIPALPIDA
Whip-Scorpions

LEGS SHORTER THAN BODY



SOLPUGIDA
Sun Spiders

LEGS MUCH LONGER THAN BODY



PHALANGIDA
Daddy Long-Leg Spiders

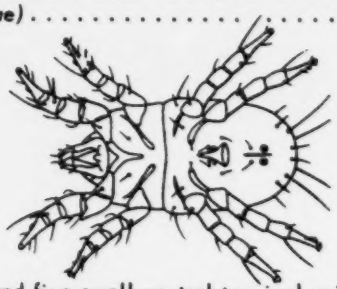
KEY TO SOME MITES COMMONLY INFESTING HOUSEHOLDS AND STORED FOOD

HAROLD GEORGE SCOTT, Ph.D.

1. With club-like hair between bases of legs I and II 5
   Without club-like hair between bases of legs I and II 2

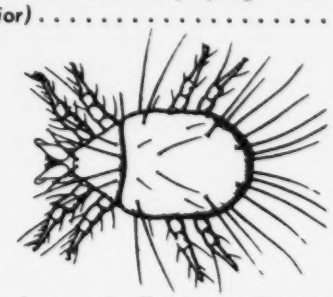
2. Claws, if present, not on stalks (*Glycyphagus domesticus*, formerly *Glyciphagus prunorum*) ..... SUGAR MITE
   Claws on stalks 3

3. Internal apical hair (on joint between femur I and tibia I) less than three times as long as external apical hair 4
   Internal apical hair (on joint between femur I and tibia I) more than three times as long as external apical hair (*Acarus farinae*, formerly *Tyroglyphus farinae*) ..... HAM MITE



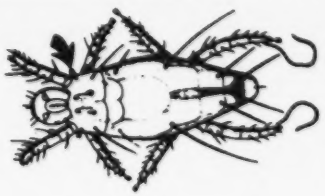
Acarus farinae

4. Tarsus with one stout dorsal and five small ventral terminal spines (*Acarus siro*, formerly *Tyroglyphus siro*) ..... GRAIN MITE
   Tarsus with only three small ventral spines (*Tyrophagus castellani*, formerly *Tyroglyphus longior*) ..... CHEESE MITE



Tyrophagus castellani

5. Tarsus IV of female ending in claws and a fleshy protuberance; leg IV of male smoothly curved inwards (*Pyemotes ventricosus*, formerly *Pediculoides ventricosus*) ..... STRAW ITCH MITE
   Tarsus IV of female ending in two long hairs of unequal length; leg IV of male sharply bent (*Tarsonemus floricolus*) ..... FLORICOLUS GRAIN MITE



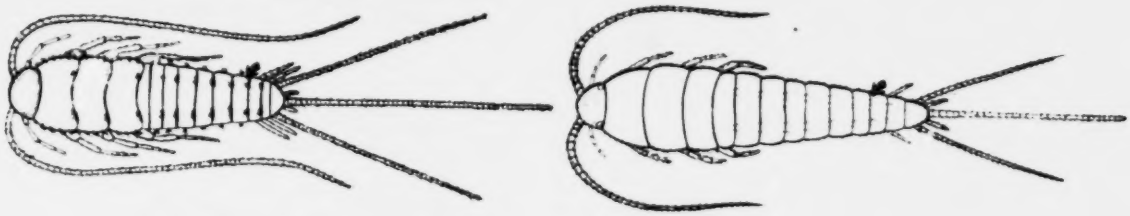
Pyemotes ventricosus

SILVERFISH
PICTORIAL KEY TO DOMESTIC SPECIES

Chester J. Stojanovich and Harold George Scott

setae in tufts
color brown

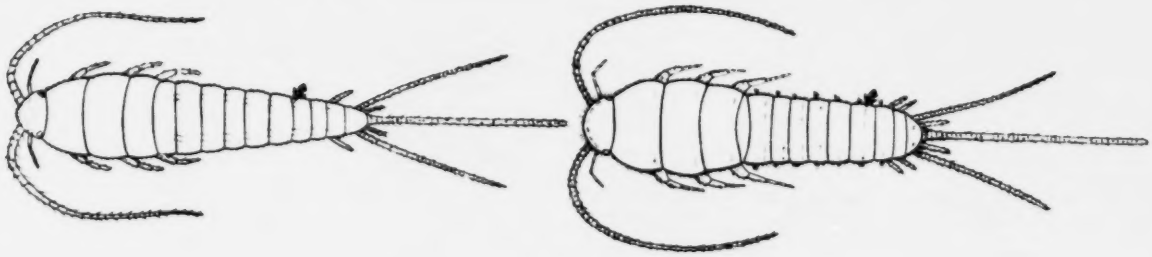
setae single



Thermobia domestica
FIREBRAT

without setal combs
color silver

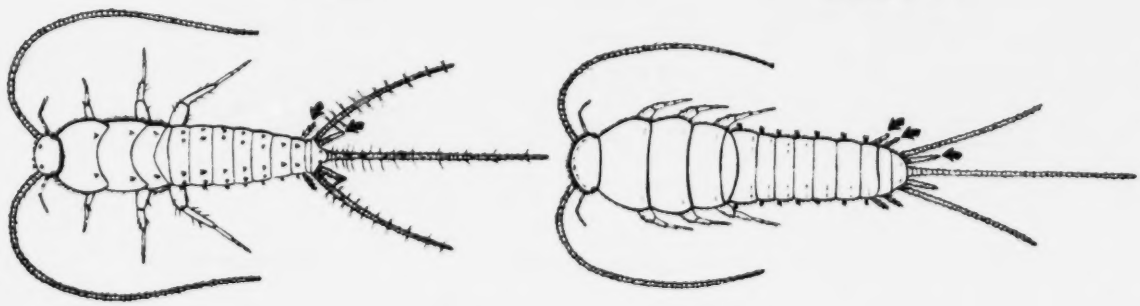
with setal combs



Lepisma saccharina
COMMON SILVERFISH

2 pairs of styli
color gray

3 pairs of styli
color brown

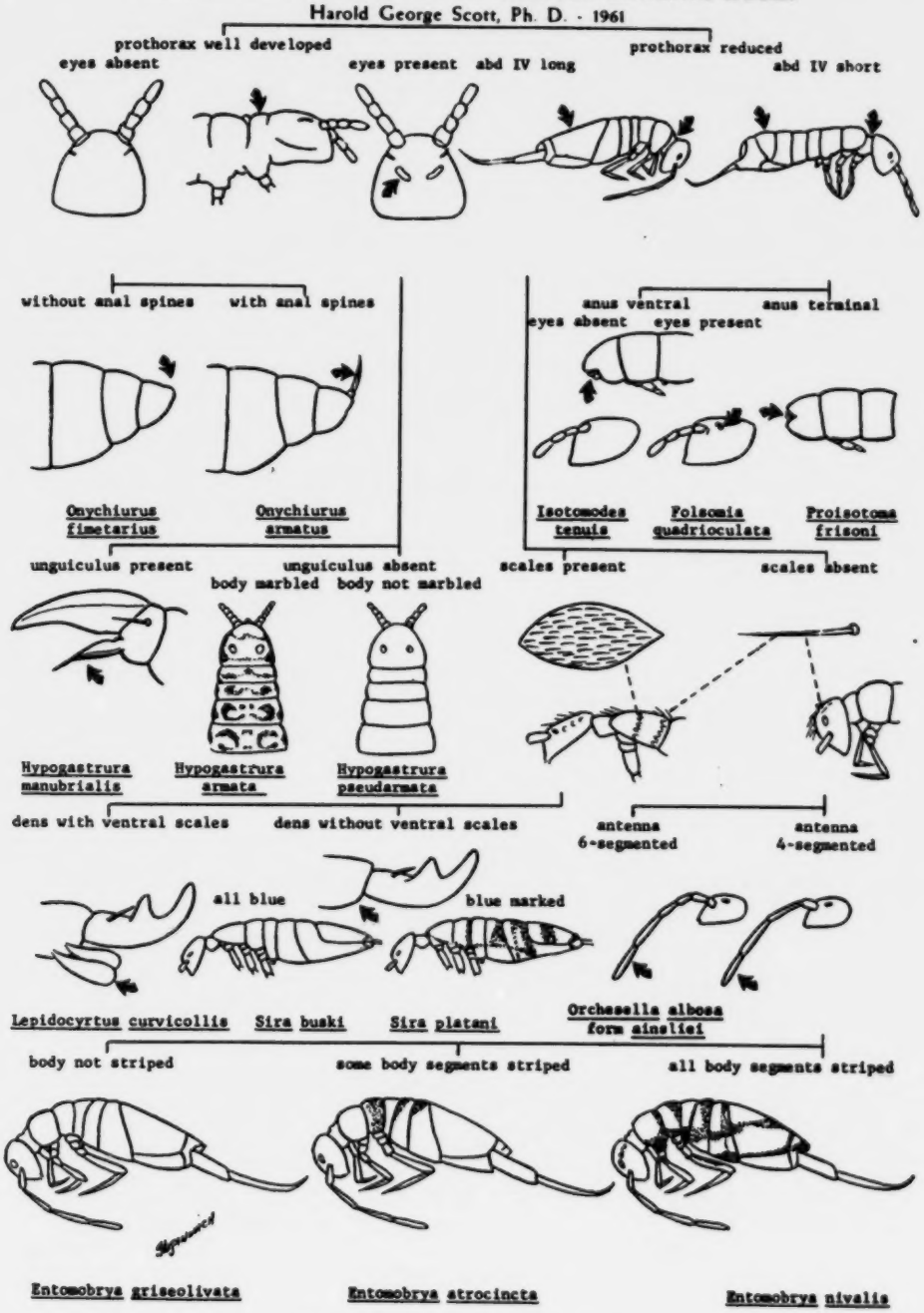


Ctenolepisma urbana
GIANT SILVERFISH
Ctenolepisma longicauda of some authors

Ctenolepisma quadriseriata
FOUR-LINED SILVERFISH

COLLEMBOLA: PICTORIAL KEY TO COMMON DOMESTIC SPECIES

Harold George Scott, Ph. D. - 1961



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ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA
Volume 55, Number 4, pp. 428–430, July 1962

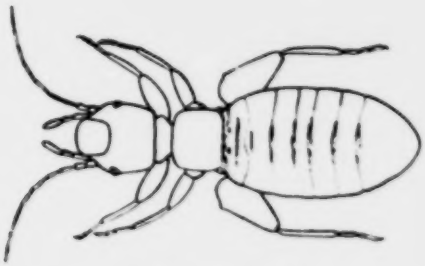
PSOCIDS: KEY TO SOME SPECIES COMMONLY INFESTING STORED FOOD

HAROLD GEORGE SCOTT and CHESTER J. STOJANOVICH

1. Two distinct thoracic segments 2
   Three distinct thoracic segments (*Trogium pulsatorium*) ..... DEATH WATCH

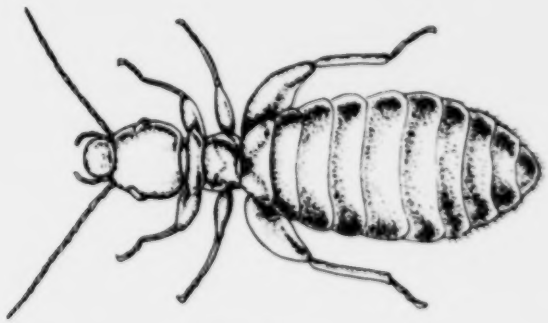
2. Without large pronotal bristles 3
   With large pronotal bristles 4

3. Eye with 7 facets; head and body brown (*Liposcelis bostrychophilus*) ..... BANDED PSOCID
   Eye with 2–4 facets; head brown, body yellow (*Liposcelis paetus*) ..... WAREHOUSE PSOCID



Warehouse Psocid

4. Two to 5 large pronotal bristles (*Liposcelis entomophilus*) ..... GRAIN PSOCID
   One large pronotal bristle (*Liposcelis terricolus*) ..... BOOK LOUSE

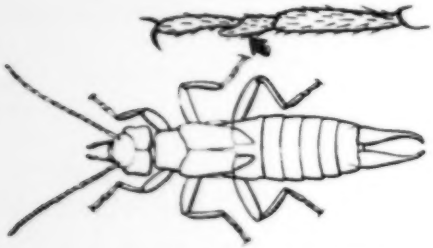


Book Louse

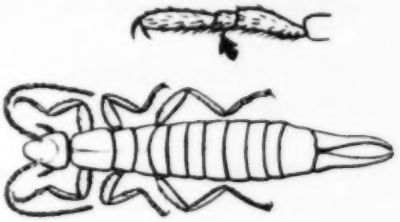
EARWIGS: PICTORIAL KEY TO COMMON DOMESTIC SPECIES

Chester J. Stojanovich and Harold George Scott

tarsus II prolonged beneath III

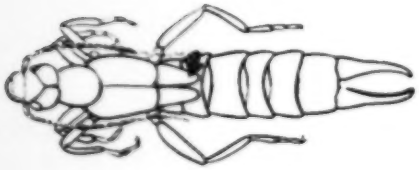


tarsus II not prolonged beneath III

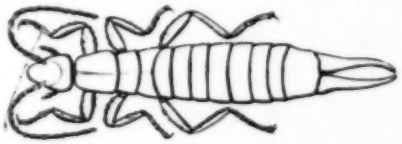


EUROPEAN EARWIG
Forficula auricularia

wings present

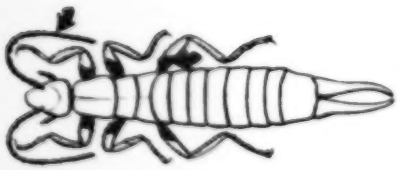


wings absent



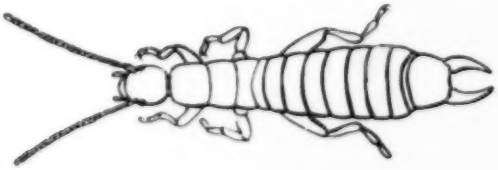
SHORE EARWIG
Labidura riparia

legs and antennae banded



RING-LEGGED EARWIG
Euborellia annulipes

legs and antennae not banded

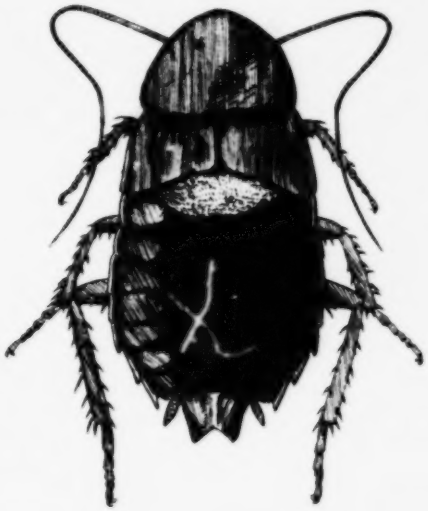


SEASIDE EARWIG
Anisolabis maritima

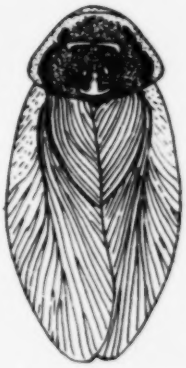
COCKROACHES: SOME SPECIES LESS COMMONLY FOUND IN HOUSES

(Not included in pictorial key)

SURINAM COCKROACH
Pycnoscelus surinamensis

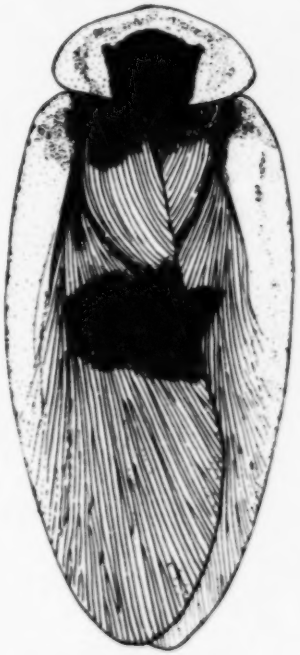


LARGE FLORIDA COCKROACH
Eurycotis floridana

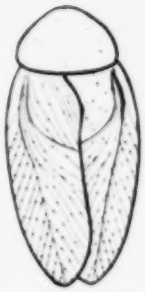


CINEREOUS COCKROACH
Nauphoeta cinerea

MADEIRA COCKROACH
Leucophaea maderae

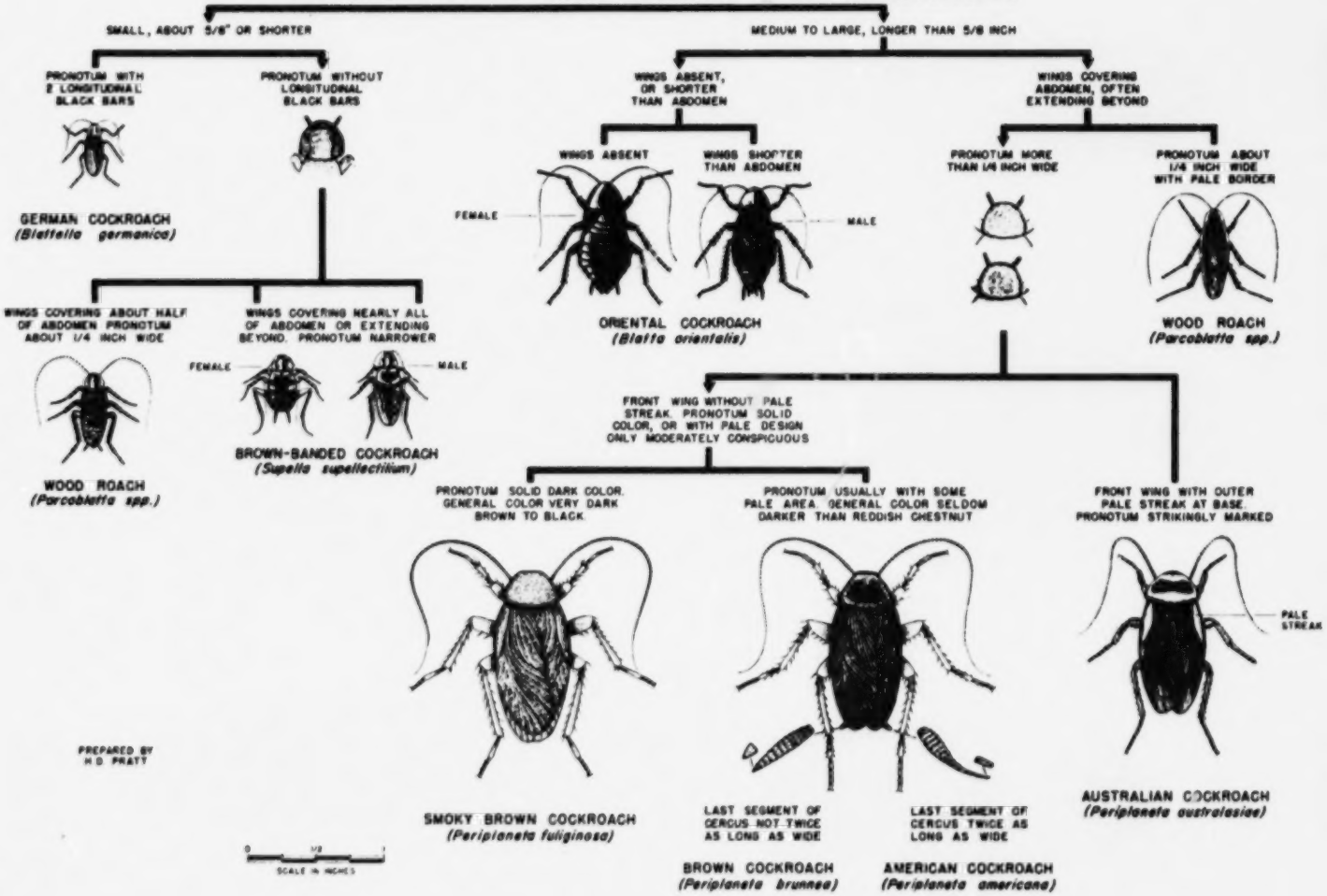


GIANT COCKROACH
Blaberus giganteus



SPOTTED MEDITERRANEAN COCKROACH
Ectobius livens

PICTORIAL KEY TO SOME COMMON ADULT COCKROACHES


SMALL, ABOUT 5/8" OR SHORTER
MEDIUM TO LARGE, LONGER THAN 5/8 INCH
PRONOTUM WITH 2 LONGITUDINAL BLACK BARS
PRONOTUM WITHOUT LONGITUDINAL BLACK BARS
GERMAN COCKROACH (Blattella germanica)
WINGS ABSENT, OR SHORTER THAN ABDOMEN
WINGS COVERING ABDOMEN, OFTEN EXTENDING BEYOND
WINGS ABSENT
WINGS SHORTER THAN ABDOMEN
FEMALE
MALE
ORIENTAL COCKROACH (Blatta orientalis)
PRONOTUM MORE THAN 1/6 INCH WIDE
PRONOTUM ABOUT 1/4 INCH WIDE WITH PALE BORDER
WOOD ROACH (Parcoblatta spp.)
WINGS COVERING ABOUT HALF OF ABDOMEN PRONOTUM ABOUT 1/4 INCH WIDE
WINGS COVERING NEARLY ALL OF ABDOMEN OR EXTENDING BEYOND. PRONOTUM NARROWER
FEMALE
MALE
BROWN-BANDED COCKROACH (Supella supellectilium)
WOOD ROACH (Parcoblatta spp.)
FRONT WING WITHOUT PALE STREAK. PRONOTUM SOLID COLOR, OR WITH PALE DESIGN ONLY MODERATELY CONSPICUOUS
PRONOTUM SOLID DARK COLOR. GENERAL COLOR VERY DARK BROWN TO BLACK
PRONOTUM USUALLY WITH SOME PALE AREA. GENERAL COLOR SELDOM DARKER THAN REDDISH CHESTNUT
FRONT WING WITH OUTER PALE STREAK AT BASE. PRONOTUM STRIKINGLY MARKED
PALE STREAK
SMOKY BROWN COCKROACH (Periplaneta fuliginosa)
LAST SEGMENT OF CERCUS NOT TWICE AS LONG AS WIDE
LAST SEGMENT OF CERCUS TWICE AS LONG AS WIDE
BROWN COCKROACH (Periplaneta brunnea)
AMERICAN COCKROACH (Periplaneta americana)
AUSTRALIAN COCKROACH (Periplaneta australasiae)
PREPARED BY H.D. PRATT
0
1/2
SCALE IN INCHES

KEY TO SOME COMMON NORTH AMERICAN TERMITES

Fig. A - Winged Adult

Fig. B - Soldier

Fig. C - Worker

Key to Winged Adults

1. Radius without branches; fontanel (fig. E) usually present 2
   Radius (fig. D) with branches; fontanel absent 4

2. Tibia (fig. F) slightly to plainly blackish 3
   Tibia entirely pale; Ontario to Guatemala, west to Utah and Arizona
   (*Reticulitermes flavipes*) ..... EASTERN SUBTERRANEAN TERMITE

3. Tibia slightly darkened; length 9 mm.; British Columbia to Baja California, east to Idaho and Sonora
   (*Reticulitermes hesperus*) ..... WESTERN SUBTERRANEAN TERMITE
   Tibia generally darkened; length 9.5- 10 mm.; Oregon and Montana to western Mexico, Missouri, and Texas
   (*Reticulitermes tibialis*) ..... ARID SUBTERRANEAN TERMITE

4. Ocelli (fig. E) present 5
   Ocelli absent; western Canada to Baja California
   (*Zootermopsis angusticollis*) ..... WESTERN ROTTEN-WOOD TERMITE

5. Body yellow to light brown 6
   Body blackish; California to Baja California, east to Arizona and Utah
   (*Kalotermes minor*) ..... WESTERN DRY-WOOD TERMITE

6. Transverse rows of long hairs on tergites; South Carolina to Florida, west to eastern Texas (*Kalotermes snyderi*) ..... EASTERN DRY-WOOD TERMITE
   No transverse rows of hairs on tergites; Arizona and California
   (*Procryptotermes hubbardi*) ..... ARID DRY-WOOD TERMITE

Fig. D - Wing

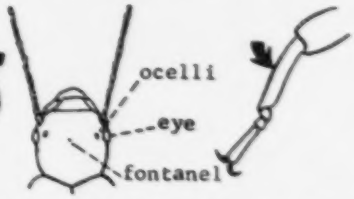


Fig. E - Head

Fig. F - Leg

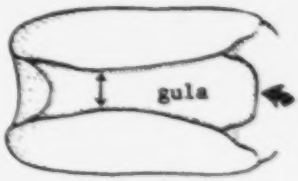


Fig. G - Throat

Key to Soldiers

1. Fontanel (fig. E) present; eyes usually absent 2
   Fontanel absent; eyes (fig. E) present 4

2. Gula (fig. G) not twice as broad in front as in middle ..... ARID SUBTERRANEAN TERMITE
   Gula twice as broad in front as in middle 3

3. Head twice as long as broad ..... WESTERN SUBTERRANEAN TERMITE
   Head less than twice as long as broad ..... EASTERN SUBTERRANEAN TERMITE

4. Antenna (fig. E) with 23-31 segments 5
   Antenna with 10-20 segments ..... WESTERN ROTTEN-WOOD TERMITE

5. Third antennal segment as long as next 3 combined ..... EASTERN DRY-WOOD TERMITE
   Third antennal segment shorter than next 3 combined ..... WESTERN DRY-WOOD TERMITE
   Third antennal segment as long as next 4 combined ..... ARID DRY-WOOD TERMITE

HAROLD GEORGE SCOTT, Ph.D.

PICTORIAL KEY TO SOME ADULT BUGS THAT MAY BITE MAN

Harry D. Pratt and Chester J. Stojanovich

wings usually well-developed; body elongate-oval

ASSASSIN AND KISSING BUGS–FAMILY REDUVIIDAE

thorax with cog-wheel crest

WHEEL BUG
Arilus cristatus

fore-wing with 2 yellow spots

CORSAIR
Rasahus biguttatus

antenna inserted midway between eye and tip of head; beak slender, straight

KISSING BUG
Triatoma spp

pronotum constricted behind middle

BLACK BUG
Melanolestes picipes

thorax without crest

fore-wing dark in U. S. species

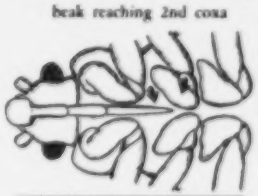
MASKED HUNTER
Reduvius personatus

pronotum constricted before middle

wings reduced; body broadly-oval

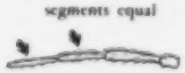
BED BUGS–FAMILY CIMICIDAE

middle coxae nearly touching
beak reaching 2nd coxa



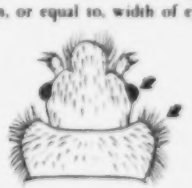
POULTRY BUG
Haematosiphon inodorus

3rd and 4th antennal segments equal



BARN SWALLOW BUG
Oeciacus vicarius

fringe hairs on pronotum longer than, or equal to, width of eye



BAT BUGS
Cimex adjunctus E. N. AM.
Cimex pilosellus W. N. AM

pronotum with anterior margin moderately excavated

TROPICAL BED BUG
Cimex hemipterus
SO. U.S. & TROPICS

middle coxae widely separated
beak not reaching 2nd coxa

4th antennal segment shorter than 3rd

fringe hairs on pronotum shorter than width of eye

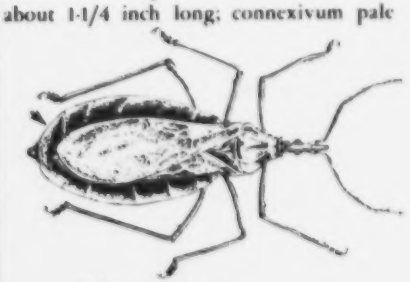
pronotum with anterior margin deeply excavated

BED BUG
Cimex lectularius
TEMPERATE AREAS

PICTORIAL KEY TO SOME COMMON KISSING BUGS IN THE UNITED STATES

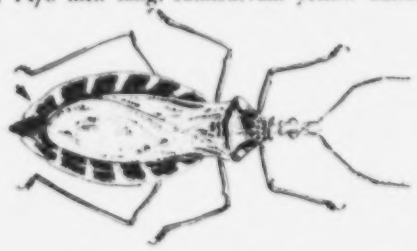
Harold George Scott, Ph.D.

about 1-1/4 inch long; connexivum pale



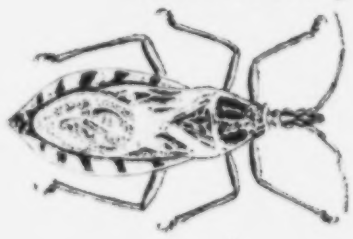
Triatoma recurva

about 1-1/8 inch long; connexivum yellow banded

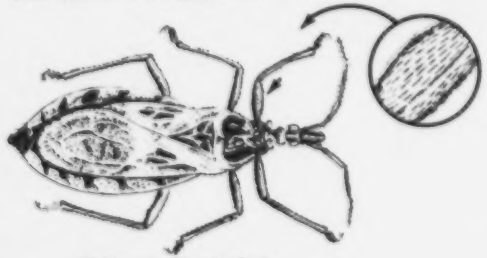


Triatoma gerstaeckeri

less than 1 inch long

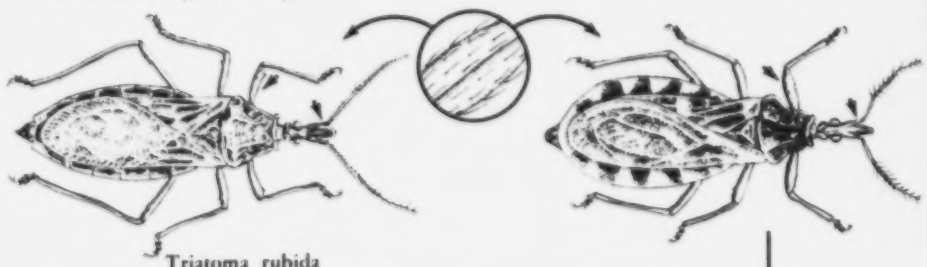


first femur with thick hair



Triatoma lecticularius

first antennal segment long ◄ first femur with sparse hair ► first antennal segment short

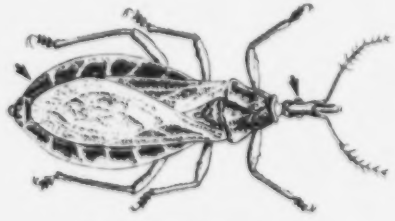


Triatoma rubida

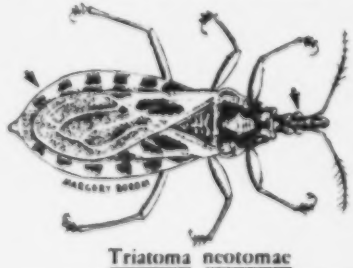
eyes large

Triatoma sanguisuga

connexivum brown, pale banded or not ◄ eyes small ► connexivum yellow banded



Triatoma protracta



Triatoma neotomae

XII–37

KEY TO SOME MOTHS COMMONLY ASSOCIATED WITH STORED FOOD

HAROLD GEORGE SCOTT, Ph.D.

1. Caterpillars 2
   Adult moths 5

2. Pinkish larvae up to 3/5-inch long living in silken tubes and producing matter webbing in the infested food *(Anagasta kuhniella)* . . . . . MEDITERRANEAN FLOUR MOTH
   Whitish larvae with or without black or orange markings 3

3. Black head and prothorax; orange markings at both ends of the body; living in silken tubes *(Pyralis farinalis)* . . . . . MEAL MOTH
   Without black head and prothorax 4

4. White to greenish-white larvae producing matter webbing in the infested food *(Plodia interpunctella)* . . . . . INDIAN MEAL MOTH
   Whitish; not producing matted webbing; living inside kernels of grain *(Sitotroga cerealella)* . . . . . ANGOUMOIS GRAIN MOTH

5. Wings unicolorous to slightly spotted; long fringe at rear of wings *(Sitotroga cerealella)* . . . . . ANGOUMOIS GRAIN MOTH
   Wings heavily dark marked 6

6. Distal half of front wings dark; basal half light *(Plodia interpunctella)* . . . . . INDIAN MEAL MOTH
   Wings not so marked 7

7. Basal and distal thirds of front wings dark; middle portion of front wings light *(Pyralis farinalis)* . . . . . MEAL MOTH
   Front wings pale gray with transverse wavy black markings *(Anagasta kuhniella)* . . . . . MEDITERRANEAN FLOUR MOTH

Angoumois Grain Moth

BLISTER BEETLES: KEY TO SOME COMMON UNITED STATES SPECIES

Harold George Scott and Chester J. Stojanovich

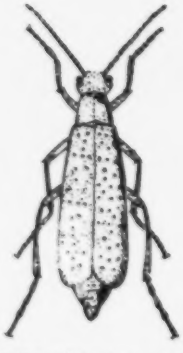
striped

Epicauta vittata
STRIPED BLISTER BEETLE

margined

Epicauta pestifera
MARGINED BLISTER BEETLE

spotted



Epicauta cinerea maculata
SPOTTED BLISTER BEETLE

essentially unicolorous

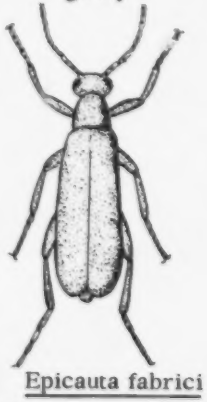
black

Epicauta pennsylvanica
BLACK BLISTER BEETLE

black with gray pubescense

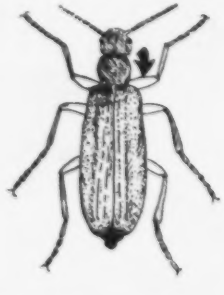
Epicauta cinerea cinerea
CLEMATIS BLISTER BEETLE

gray



Epicauta fabrici
ASH-GRAY BLISTER BEETLE

metallic blue with red-yellow leg bases



Pomphopoea sayi
SAY BLISTER BEETLE

PICTORIAL KEY TO SOME COMMON BEETLES AND WEEVILS
ASSOCIATED WITH STORED FOODS

PRONOTUM WITH 6 TEETH ON EACH SIDE
BEAK ABSENT; SPECIES ABOUT 1/8 INCH LONG

SAW-TOOTHED GRAIN BEETLE
Oryzaephilus surinamensis

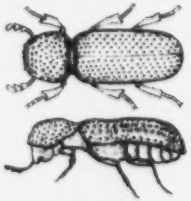
PRONOTUM WITHOUT TEETH ON EACH SIDE
BEAK ABSENT

SMALL BROWNISH SPECIES
LESS THAN 1/4 INCH LONG

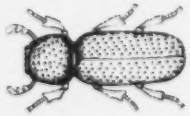
HEAD VISIBLE FROM ABOVE
1/8 INCH LONG OR MORE

CONFUSED AND RED FLOUR BEETLES
Tribolium confusum AND *castaneum*

HEAD HIDDEN UNDER PRONOTUM
LESS THAN 1/8 INCH LONG



FORE WING WITH ROUGHENED SURFACE

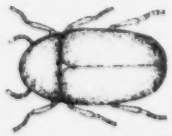


LESSER GRAIN BORER
Rhyzopertha dominica

FORE WING WITH LINES

DRUG STORE BEETLE
Stegobium paniceum

FORE WING SMOOTH



CIGARETTE BEETLE
Lasioderma serricorne

LARGER BLACKISH SPECIES
1/4 TO 3/4 INCH LONG

PRONOTUM WITHOUT TEETH ON EACH SIDE
BEAK PRESENT; SPECIES ABOUT 1/8 INCH LONG

EACH FORE WING WITH 2 PALE SPOTS
PRONOTUM WITH ROUND PUNCTURES

RICE WEEVIL
Sitophilus oryza

EACH FORE WING DARK
PRONOTUM WITH ELONGATE PUNCTURES

GRANARY WEEVIL
Sitophilus granarius

FLATTENED BEETLES
1/4 TO 1/2 INCH LONG
PRONOTUM SEPARATED BY STRONG
CONSTRICTION FROM BASES OF WINGS

CADELLE
Tenebroides mauritanicus

CONVEX BEETLES
1/2 INCH LONG OR MORE
PRONOTUM NOT SO STRONGLY
SEPARATED FROM BASES OF WINGS

YELLOW MEAL WORM
Tenebrio molitor

PREPARED BY H.D. PRATT

KEY TO SOME COMMON HOUSEHOLD AND FIRE ANTS

HAROLD GEORGE SCOTT, Ph.D.

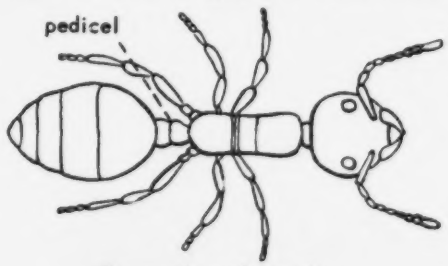
1. Pedicel ("waist") 1-segmented 2
   Pedicel 2-segmented 4

2. Petiole (scale on pedicel) poorly developed, hidden beneath abdomen
   (Tapinoma sessile) ..... ODOROUS HOUSE ANT
   Petiole well-developed, erect, not hidden beneath abdomen 3

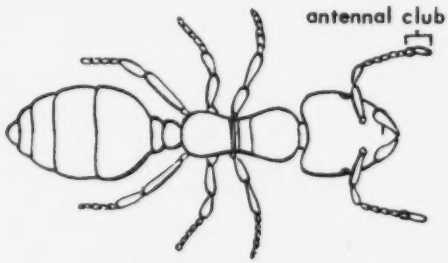
3. Tip of abdomen without circlet of hairs *(Iridomyrmex humilis)* ..... ARGENTINE ANT
   Tip of abdomen with circlet of hairs *(Camponotus herculeanus pennsylvanicus)* ..... BLACK CARPENTER ANT

4. Head and thorax with numerous spines *(Atta texana)* ..... TEXAS LEAF-CUTTING ANT
   Head and thorax spineless or with 1 pair of spines on the posterior thorax 5

5. Thorax and head covered with "fingerprints"; posterior thorax with single pairs of spines *(Tetramorium caespitum)* ..... PAVEMENT ANT
   Thorax and head without "fingerprints"; posterior thorax without spines 6



Monomorium pharaonis



Solenopsis molesta

6. Antennal club 2-segmented 8
   Antennal club 3-segmented 7

7. Shiny-black *(Monomorium minimum)* ..... LITTLE BLACK ANT
   Yellowish-red *(Monomorium pharaonis)* ..... PHARAOH ANT

8. House infesting ants *(Solenopsis molesta)* ..... THIEF ANT
   Outdoor mound-building ants 9

9. Mandibles strongly incurved *(Solenopsis geminata)* ..... TROPICAL FIRE ANT
   Mandibles not strongly incurved 10

10. Dorsal surface of head with large coarse, scattered punctures *(Solenopsis saevissima* var. *richteri)* ..... IMPORTED FIRE ANT
    Dorsal surface of head without punctures *(Solenopsis xyloni)* ..... SOUTHERN FIRE ANT

STINGING HYMENOPTERA
PICTORIAL KEY TO SOME COMMON UNITED STATES FAMILIES

Harold George Scott and Chester J. Stojanovich

wings absent

body fur-like
without node

body not fur-like
with node

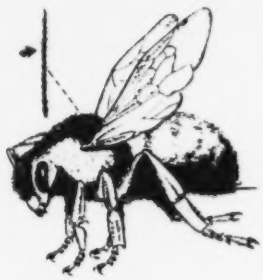
wings present

hairs not feathered
(use 20 X magnification)

hairs feathered
(use 20 X magnification)

Mutillidae
VELVET ANTS

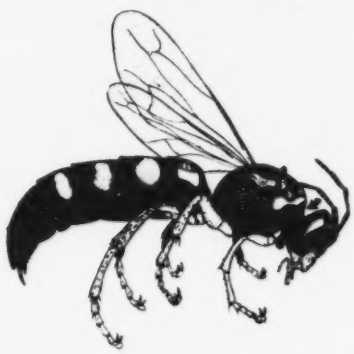
Formicidae
ANTS



pronotum long, reaching tegula

Vespidae
WASPS, YELLOW JACKETS, HORNETS

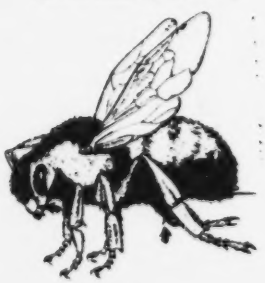
pronotum short, not reaching tegula



Sphecidae
SPHECID WASPS

hind tibia with spurs

eye not reaching mandible



Bombidae
BUMBLE BEES

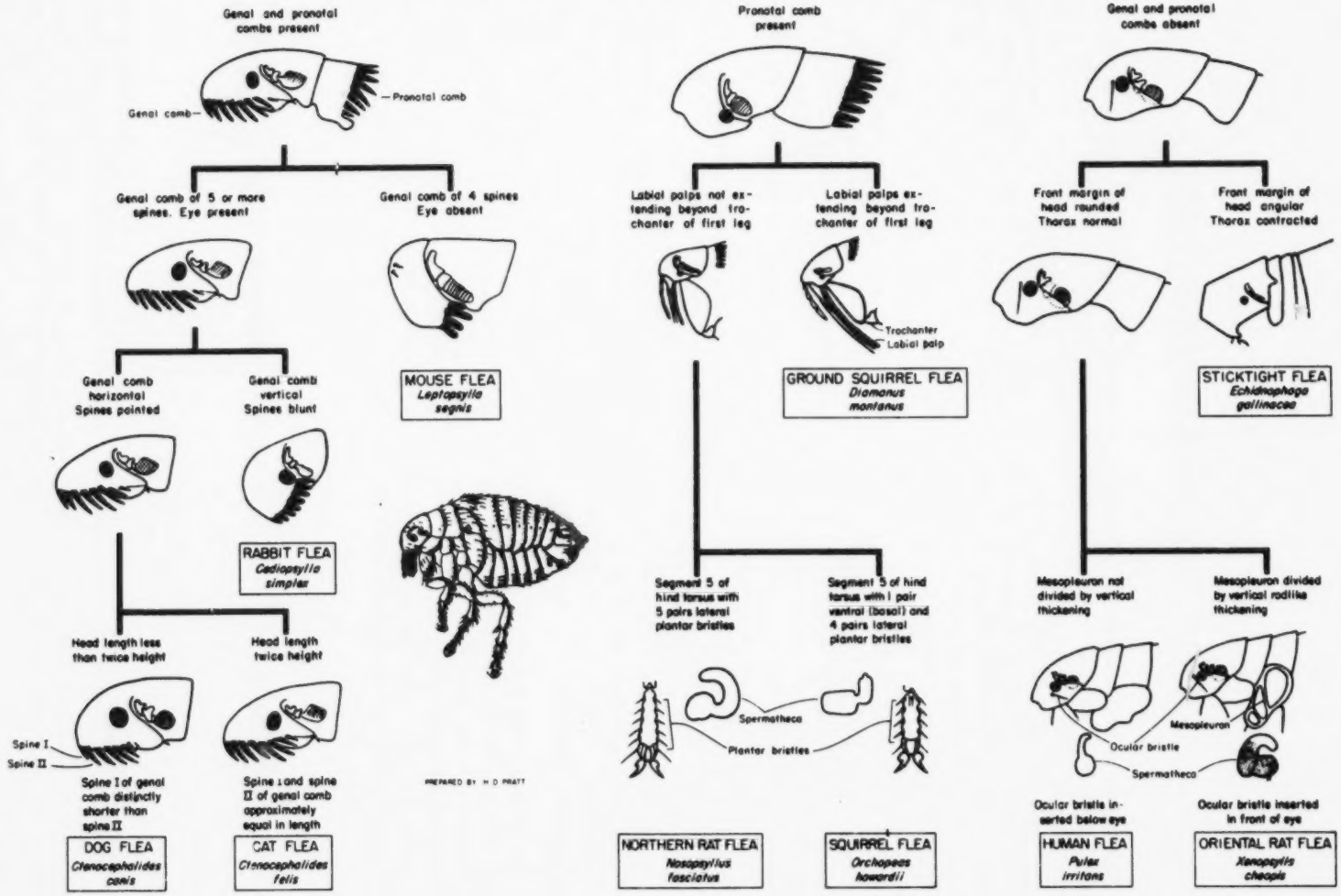
eye reaching mandible

Andrenidae
SWEAT BEES

hind tibia without spurs

Apidae
HONEY BEES

PICTORIAL KEY TO SOME COMMON FLEAS IN THE UNITED STATES


Genal and pronotal combs present
Genal comb
Pronotal comb
Genal comb of 5 or more spines. Eye present
Genal comb of 4 spines Eye absent
Genal comb horizontal Spines pointed
Genal comb vertical Spines blunt
MOUSE FLEA Leptopsylla segnis
RABBIT FLEA Cediopsylla simplex
Head length less than twice height
Head length twice height
Spine I
Spine II
Spine I of genal comb distinctly shorter than spine II
Spine I and spine II of genal comb approximately equal in length
DOG FLEA Ctenocephalides canis
CAT FLEA Ctenocephalides felis
PREPARED BY H O PRATT
Pronotal comb present
Genal and pronotal combs absent
Labial palps not extending beyond trochanter of first leg
Labial palps extending beyond trochanter of first leg
Trochanter
Labial palp
GROUND SQUIRREL FLEA Diamanus montanus
Front margin of head rounded Thorax normal
Front margin of head angular Thorax contracted
STICKTIGHT FLEA Echidnophaga gallinacea
Segment 5 of hind tarsus with 5 pairs lateral plantar bristles
Segment 5 of hind tarsus with 1 pair ventral (basal) and 4 pairs lateral plantar bristles
Spermatheca
Plantar bristles
NORTHERN RAT FLEA Nosopsyllus fasciatus
SQUIRREL FLEA Orchopeas howardii
Mesopleuron not divided by vertical thickening
Mesopleuron divided by vertical rodlike thickening
Mesopleuron
Ocular bristle
Spermatheca
Ocular bristle inserted below eye
Ocular bristle inserted in front of eye
HUMAN FLEA Pulex irritans
ORIENTAL RAT FLEA Xenopsylla cheopis

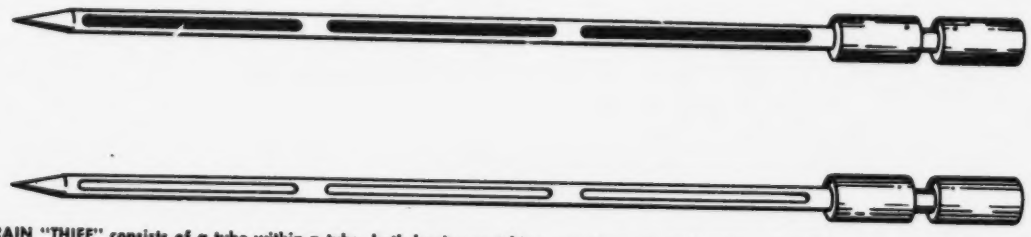
SURVEY FOR STORED-FOOD INSECTS

Periodic careful inspection of stored foods susceptible to insect attack is essential to the insect control program (Hollett, 1959). Most insects have a very high reproductive potential which, combined with a short cycle, permits an incipient infestation to become damaging within a short period of time. The inspector should regard each new shipment as suspect and should not assume that the apparent absence of insects means that none are present. Cereals with less than one insect per pound may become heavily infested within 30 days, requiring that they be sold for animal feed or destroyed. Early detection of insect infestations, plus prompt control measures make it possible to save valuable food stocks. The inspector will need a flashlight, vials and pillboxes, hand lens, and suitable samplers in order to make an inspection. A sampler, or "thief" is a tool for removing coffee, corn, rice, or other products from a sack without damaging the sack. It is usually not practical to sample closed cartons or food in multiwall bags unless there is good reason to suspect infestation. If food is not kept in these types of containers for long periods of time, the danger of loss is small.

The inspector proceeds throughout the warehouses, at weekly intervals during the warm months and at monthly intervals during the cool months, stopping at each location where susceptible food is stored. Canned foods, sugar, and other items not highly susceptible to damage are usually bypassed or given a cursory examination. Beans, hams, cereals, and improperly packaged cheeses are examined carefully. It is a good practice to check windows for flying insects and to examine floors, pallets, and walls for insects that have emerged. Insects affecting sacked grains and cereal products are found on the exterior of the bags and at the ends where the bags are stitched. The flashlight is used in examining these locations, and specimens are collected for identification. The lot number of each shipment is recorded in a notebook, together with the date of receipt, origin of the shipment, date infestation was discovered, and name of the inspector. Should destructive pests be found, sample the contents to determine the condition of the food and the abundance of infesting insects.

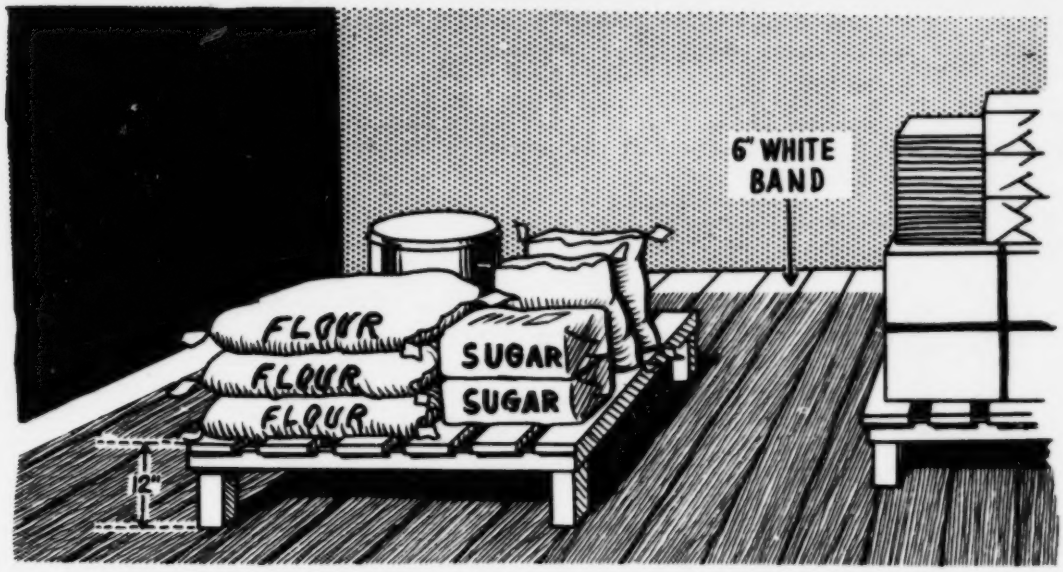
Infested materials can be saved sometimes if prompt action is taken to assure that the products will pass the standards of the Food and Drug Administration. Immediate fumigation of lightly infested materials will often suffice, but heavily infested materials can rarely be put to use as human food. Flour may be rebolted to remove most of the infesting insects, but the minute fecal matter and eggs are not removed. The inspector can perform a valuable service by keeping in touch with warehousemen and informing them of unsatisfactory conditions. Large shipments of susceptible items are often given a cursory examination and placed in storage with older items with the result that insects are soon spread throughout the entire warehouse. After

Figure 12.32



A GRAIN "THIEF" consists of a tube within a tube, both having matching openings ½ inch wide. Inserted open, the 36-inch sampler secures a core from top to bottom of the grain being examined. Upon reaching the desired depth, the handle is turned to revolve the inner tube and close it.

Figure 12.33



Good sanitation, proper warehousing, and rotation of stocks are the most important practices for preventing insect infestation of food products.

a warehouse has been freed of insects, it is especially important to examine incoming stocks carefully to avoid introducing new infestations. Items may be inspected while in freight cars or on loading platforms before being placed in storage. One inspection method used is sampling from some of the packages and placing the food in incubators so that insects may emerge and be detected. A method of detecting feces in flour is to shake the flour in a flask with a saturated salt solution containing gasoline (35 ml. of gasoline; 200 ml. of salt solution; 50 g. of flour). The flask is allowed to stand for 30 minutes, stirring at 5-minute intervals without disturbing the gasoline layer. A trap flash is used to collect floating material which is examined for insect and rodent feces (U.S. Food and Drug Adm., 1960).

CONTROL OF HOUSEHOLD INSECTS

BASIC SANITATION routinely employed protects households from annoyance, debility, death, and economic loss associated with insect infestations. When vector populations are large, probability of disease transmission and economic loss is high. Basic sanitation prevents development of large populations by depriving insects of food, haborage, and breeding media. Although insecticides may produce temporary pest reduction, only permanent techniques such as sanitation and pest-proofing bring about long-term control (Johnson, 1960).

Refuse storage in a sanitary manner is a fundamental factor in effective household insect control. Wrap garbage in paper, and store in durable, rustproof cans which are kept clean and covered. Provide enough containers so refuse need never be stored in boxes, cartons, bags, or on the ground. Keep cans on neat, easily cleaned racks, platforms, or slabs. Avoid spillage of garbage on soil. Remove paper, boards, cardboard, loose rock, etc. from basements and yards to control scorpions, spiders, centipedes, and other pests and to improve premise appearance. One of the greatest opportunities for household insect control lies in better refuse storage and litter removal.

Human wastes, loaded with organisms pathogenic to man, are among the greatest hazards to public health. In addition, they provide excellent breeding media for flies and other insects. Therefore, all human wastes should be disposed of immediately in the most sanitary manner available. Where sewage is water-borne, it is a disposal problem for community sewage plants or community regulated septic tanks. Where it is not water-borne, it should be disposed of in a sanitary pit privy.

Standing water, a source of mosquitoes (vectors of encephalitis, malaria, etc.) and other insects, should be drained, the cavity filled, or maintained in a sanitary condition (clean shore line, no emergent vegetation). Many health departments have regulations governing maintenance of standing water. These should be investigated and followed. Special attention should be given to removing small accumulations of water (as in small containers) from premises.

Structural harborage is provided by any item suitable as a hiding place for cockroaches, bed bugs, or other pests. New buildings should be constructed as pest proof as possible. Older buildings should be modified with screens, etc., so they present a minimum of harborage for pests.

Vacuum cleaning at regular intervals (at least once weekly) plays an important role in insect reduction. It is of especial value in household flea control. Vacuum cleaning picks up not only adult fleas, but (of greater significance) eggs, larvae, and pupae in cracks of flooring and fibers of rugs and overstuffed furniture. It thus prevents build-up of large flea populations from the few brought into the house by pets. Vacuum cleaning also reduces infestations of ticks, mites, food and fabric insects, and other pests.

Weeds are an open invitation for large insect populations to come near human habitations. They provide extensive and varied cover for the pests, and prevent adequate control of refuse, feces, standing water, and structural harborage. Use weed killers (2,4–D; 2,4,5–T; and others) when safe and practical. Use mowers, clippers, weed burners, etc. when weed killers might endanger valuable plant life.

Food storage is an important factor in household insect control. Poor storage produces large populations of beetles, moths, cockroaches, and other pests. Inspect food periodically. Isolate infested materials immediately from clean stock. Rotate food so the oldest material is always used first. Keep new stocks away from older items.

Storage of usable items should be arranged to reduce food and harborage for pests to a minimum, and to eliminate fire hazards. Stack items on racks 18 inches off the ground. Keep objects which might accumulate water under cover. Evaluate stored items critically, and dispose of those unlikely to have real future value.

CHEMICAL CONTROL of household insects is often desirable, but is a temporary control measure, and should be supported by good sanitation as described above.

Where *flies* congregate, use residual sprays (5% premium grade malathion emulsion indoors, 5% mala-

thion–12½% sugar outdoors at 1 gal./950 square feet); space sprays (0.1% synergized pyrethrum or allethrin indoors at 8 oz./10,000 cubic feet; 5% DDT, 1% lindane, or 3% malathion outdoors at 2.5 gal./acre); install insecticide impregnated cord (10% parathion or 25% diazinon cord at 30 linear ft./100 square feet of floor; purchase cords ready-made, do not attempt to manufacture), or larvicide (2% chlordane, 1% lindane, or 2.5% diazinon).

For *mosquito* control, use repellents (diethyl-toluamide, indalone, Rutgers 612, or 622), residual sprays (5% DDT, 3% malathion at 1 gal./950 square feet), space sprays (0.1% synergized pyrethrum or allethrin indoors at 8 oz./10,000 cubic feet; 1% lindane or 3% malathion outdoors at 2.5 gal./acre), or larvicide (1.25% DDT or 0.625% malathion solution mists at 2 gal./acre). Higher concentrations endanger fish.

For *cockroach* control, pin-stream spray insecticides (2.5% chlordane, 1% lindane, 2% malathion, or 0.5% diazinon emulsion) into cracks and crevices in walls, baseboards, furniture, fixtures, cabinets, and other places cockroaches hide. Blow finely-powdered silica gel, 5 percent chlordane dust, or 3 percent malathion dust into dead spaces, or on electric wires, fuse boxes, and other items which sprays might damage.

For *bed bug* or *kissing bug* control, spray infested dwelling with 5 percent DDT emulsion, giving special attention to cracks and crevices in and near beds and upholstered furniture. Thorough application is essential. Use 1 percent lindane on bugs which have become resistant to DDT.

For *flea* control, dust infested houses, yards, and animals (except cats) with 5 percent DDT or 3 percent malathion. Dust cats with 3 percent malathion or 1 percent rotenone. Spray infested houses or yards with 5 percent DDT or 2 percent malathion emulsion. Always treat house throughly before leaving it empty for an extended period. Routine preventive dusting of pets will aid in keeping large infestations from developing.

Control *chiggers* and other field *mites* with residual sprays (5% ovex, 1% dieldrin, 2% malathion, or 2% chlordane at 1 gal./950 square feet); or dusts (10% ovex, 2% dieldrin, 5% chlordane, or 4% malathion at 20 lb./acre). Use diethyl-toluamide repellent. Impregnate clothing as for ticks.

Spray *spiders* and webs with 1 percent lindane or 2 percent chlordane. Spray 2 percent chlordane or 0.5 percent dieldrin where *scorpions* or *centipedes* hide.

CONTROL OF STORED-FOOD INSECTS

Man's custom of storing food for later consumption provides insects an easy living. Some pests live in the fields and fly into storehouses or are transported in with infested food. Others live only in stored food, and invade fresh material which is brought in. If the storehouse provides favorable moisture, temperature, and harborage, tremendous economic loss may result, and personnel are exposed to insect-borne disease. Much of the damage and disease hazard can be prevented by making use of an adequate knowledge of the life histories and habits of the infesting insects (Cotton, 1956; Henderson, 1955; Herr, 1957; Mallis, 1960; Metcalf, *et al.*, 1962). Stored-food insect control should be conducted on a year-around basis (Rilett, 1956).

SANITATION

Cleanliness is an important factor in preventing insect damage to stored products. Many warehouses have become highly infested because flour, rice, or other foods have been spilled upon the floors and allowed to remain for long periods of time to reinfest each new shipment of clean merchandise placed in storage. It is essential that all torn bags be repaired immediately, that floors be kept clean, and that efforts be directed toward preventing contamination of stored food products. Ceilings, floors, walls, and bins should be free of cracks so that harborage for stored food pests is not "built in" (Michelbacher, 1957; Mielke, 1957; Parker, 1962).

PALLETIZING

Proper practice in food storage does not allow placing cartons, bags, and other containers of goods directly upon the floor. Oak or pine pallets are employed to store these items, each pallet containing a load that may be transported from place to place by hydraulic lift. Cartons or bags must be placed upon the pallets by hand labor; but, after this operation, machinery can be used in transporting the palletized stocks from place to place. There is a trend toward shipping material on pallets, so that the merchandise can be loaded and unloaded by machinery. Cereal products or other foods must not be stacked against warehouse walls or ceilings, as this prevents adequate inspection and creates a fire hazard. Stacking food products against the walls also increases the amount of rodent harborage. Stacks should not be so high that they crush cartons and bags as this will increase the probability of infestation.

ROTATION

Rotation of stocks is an important factor in preventing losses due to insects. If old stocks are allowed to remain in storage for long periods of time, the insects may complete one or more life cycles; and light infestations may become damaging ones. Old stocks remaining on hand may infest stocks subsequently received. The accumulation of dirt and filth, rodent urine or feces, and moisture may result in the eventual loss of valuable foodstuffs. Food stored under such conditions is especially subject to insect attack, and the formation of mold may impart an off-flavor.

ISOLATION

It is important to isolate new stocks of susceptible items from the old supply. Often a carload of feed or flour is stacked on or near a few remaining sacks of old infested materials. This results in the immediate infestation of the new shipment. Susceptible items must be stored as remotely as possible from old stocks whether the infestation is heavy or light, or even if the material is believed to be free from infestation.

VENTILATION: MOISTURE AND TEMPERATURE CONTROL

Adequate ventilation is important in the storage of dry foods. A high moisture content is conducive to attack by insects and mites and the formation of mold. Ventilation may be provided by 3-foot access aisles between stacks of stored items, a 3-foot space between stacks and the walls, and 2 feet between the stacks and the ceiling. Ventilators and doors should be opened during dry weather and closed during periods of excessive humidity. During the winter it is

THE CHEMICAL CONTROL OF INSECTS

INSECTICIDES

REPELLENTS
- Diethyltoluamide
- Indalone
- Rutgers 612
- Dimethylphthalate
- Dibutylphthalate

ATTRACTANTS
- Geraniol
- Eugenol
- Terpinylacetate
- Anethol
- Metaldehyde
- Ammonia
- Saccharine

IMPREGNANTS
- Benzil
- Benzylbenzoate
- Benzocaine
- M-1960
- Mitin
- Eulan
- Beconizer

AUXILIARIES
- Synergists
- Inhibitors
- Solvents
- Emulsifiers
- Wetting Agents
- Spreaders
- Perfumes
- Diluents

Contact Poisons

INORGANIC

SULFUR GROUP
- Sulfur
- Lime-sulfur

MERCURY GROUP
- Calomel
- Corrosive sublimate

ORGANIC

Synthetic

NON-SUBSTITUTED HYDROCARBONS
- Formaldehyde
- Metaldehyde
- b-Naphthol
- Xanthone
- Forbom

ORGANIC CHLORINE GROUP*
- Pentachlorophenol
- BHC
- Lindane
- Methoxychlor
- DDD
- DDT
- Dilan
- Dimite
- Heptachlor
- Chlordene
- Aldrin
- Dieldrin
- Endrin

ORGANIC PHOSPHORUS GROUP
- Malathion
- Diazinon
- Parathion
- TEPP
- EPN
- HETP
- DDVP
- Dibrom
- Guthion
- Dipterex
- Entex
- Baytex
- Ronnel
- Dicapthon
- Dimethoate

ORGANIC NITROGEN GROUP
- Dinitrophenol
- DNOC
- DNOCHP
- DNOSBP
- Diphenylamine
- Azobenzene
- Karathane
- Pratan
- Dinitronaphthol
- Dinitroanisole
- Dinitrocresylate

ORGANIC SULFUR GROUP
- Aramite
- Ovex
- Sulfenone
- Phenothiazine
- Genitol
- Sevin
- Isolan
- Dimetilan
- Pyrolan

ORGANIC THIOCYANATE GROUP
- Lethane
- Thanite
- Loro

Natural

PETROLEUM GROUP
- Fuel Oil
- Kerosene

ALKALOID GROUP
- Nicotine
- Anabasine
- Hornicotine
- Sabadilla
- Hellebore
- Ryania
- Quassia

ESTER GROUP
- Pyrethrum
- Pyrethrins
- Cinerins
- (Allethrin)

ROTENOID GROUP
- Rotenone

RESIN GROUP
- Phalladendrin
- Croton Oil
- Amorphin
- Basil Oil
- Sage Oil
- Turpentine

Stomach Poisons

ARSENIC GROUP
- Arsenic trioxide
- Lead arsenate
- Copper arsenate
- Paris green

FLUORINE GROUP
- Sodium fluoride
- 1080
- Cryolite
- Sodium fluosilicate

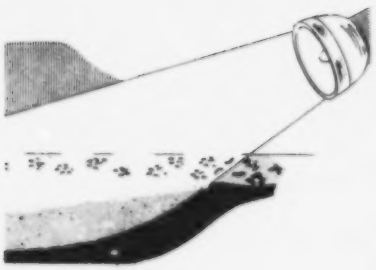
OTHER GROUPS
- Phosphorus paste
- Borax
- Tartar emetic
- SALP
- Thallium sulfate

Fumigants
- Hydrogen cyanide
- Methyl bromide
- Carbon tetrachloride
- Ethide
- Sulfur dioxide
- Naphthalene
- o-Dichlorobenzene
- p-Dichlorobenzene

HAROLD GEORGE SCOTT, Ph.D.

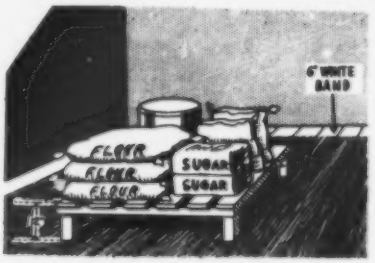
*Chlorinated Hydrocarbons

STORED FOOD PEST CONTROL



INSPECTION

SANITATION

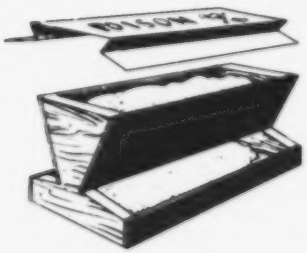


PALLETIZING

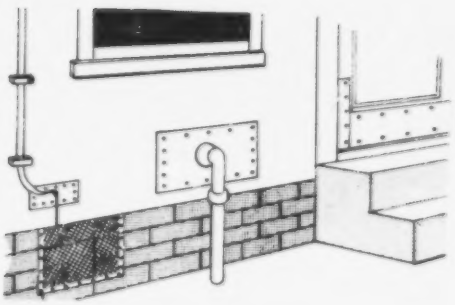
PACKAGING

SPRAYING

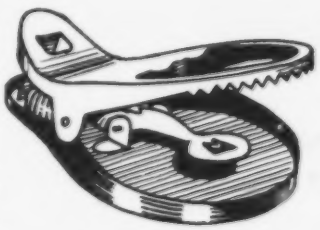
DUSTING



POISONING



STOPPAGE



TRAPPING

Figure 12.34

advantageous to permit cool air to circulate in warehouses unless this may cause damage to products subject to freezing. Grains may be subjected to extremely low temperatures without damage. Cold is a useful factor in deterring insect infestations, as most species develop slowly at low temperatures and many individual insects are killed by freezing temperatures.

PACKAGING

Careful packaging can greatly limit insect infestations in stored food (Laudani, *et al.*, 1958). In general it is best not to reuse packaging. If packaging is to be reused, it must be sterilized by heat or fumigation.

INSECT PROOFING

Grain stored in poorly constructed buildings may become infested by insects flying in from nearby fields or warehouses. Poor construction encourages rapid build-up of large populations. Carefully planned and constructed warehouses can minimize this hazard. Make the building as insect-proof as possible. Many large grain storage warehouses have built-in fumigation systems (Searls, 1956).

RESIDUAL SPRAYING

Many important stored-product insects (beetles, weevils, borers, mealworms, moths, silverfish, firebrats, springtails, psocids, and cheese maggots) are highly susceptible to DDT. Suspensions are used in food warehouses because they are non-inflammable, non-corrosive, and comparatively odorless, but they must never be applied in such a manner as to contaminate foodstuffs. DDT will remain effective until covered with dust or swept from warehouse floors. Treat floors, pillars, walls, beams, pallets, and other surfaces adjacent to susceptible stored products with 2.5 percent DDT suspension (1 gal./1000 ft.^{2}). Clean warehouse bays as they become empty, and spray with DDT before placing new items in storage. This will destroy existing insects and help prevent infestation of new stocks. A small power sprayer is suitable for making DDT applications in warehouses or storage elevators. The sprayer consists of a tank with paddle type agitators, a pump, gasoline motor, hose, and spray guns. The material should be applied as a residual spray rather than a mist. It is not always necessary to spray the floors, as a considerable amount of DDT will be deposited on the floors while treating other surfaces. Roaches, ants, and mites are controlled by spot applications of 2½ percent chlordane or 1 percent lindane emulsion. *Do not* contaminate foodstuffs (U.S. Food and Drug Adm., 1960).

SPACE SPRAYING

Space spraying equipment has been developed for killing stored-food insects. Fog applicators emit a very dense cloud, and mist machines fill the air with tiny droplets of insecticide that kill insects in flight or upon exposed surfaces. There may be some killing of insects between pallets, bags, and other locations. Such treatments do not constitute fumigation and are feasible only for destroying insects that have not penetrated bags and cartons. These treatments are regarded as preventive maintenance rather than as a means for eliminating existing infestations. Only insecticides of low toxicity to humans, such as 0.1 percent synergized pyrethrum, are suitable for fogging and misting (Lloyd and Hewlett, 1958; Schroeder, 1955).

FUMIGATION

Fumigation of stored products is the traditional means for destroying all insects infesting bins, elevators, warehouses, and storerooms (Cotton, 1956). Fumigation is dangerous and should be attempted only by qualified personnel. 0.5 percent DDVP has been used as a combination residual spray and fumigant. Food contamination must be avoided. Bins and granaries on the farm are often fumigated with a 3:1 mixture of ethylene dichloride and carbon tetrachloride. This gas is purchased as a colorless sweet-smelling liquid deadly to all forms of insect life. It will not create a fire hazard, but may asphyxiate humans. Hydrocyanic acid gas and methyl bromide are used extensively in warehouses, bins, and elevators that can be sealed tightly. Both of these materials are highly toxic to humans. There are usually pest control operators in cities and towns who have the equipment, materials, and skilled personnel needed for this type of work. BF gas has been used experimentally (Jeske, *et al.*, 1957).

Fumigation is usually accomplished in containers, vaults, buildings, or box cars at atmospheric pressure (McSpadden, 1958). More satisfactory treatment can be obtained in vacuum chambers especially developed for fumigation purposes. These installations are very expensive and are not available in all areas. Bagged and packaged materials may be completely disinfested of live insects by vacuum fumigation (methyl bromide will penetrate to the center of a 200-pound sack of flour or through cartons used for packaging cereals). These fumigations are not completely effective at atmospheric pressure, and vacuum chambers are recommended. Fumigated items must be placed in proper storage after treatment. As insect eggs are not always

killed, stocks are susceptible to reinfestation. It is not desirable to fumigate the same items repeatedly.

RADIATION

Use of radiant energy to eliminate pests from stored food has been accomplished experimentally, and has been used in a limited way in food plants. This technique will very likely become a commonly used method for stored food pest control (Hassett, 1957; Howder and Auerbach, 1958). A decrease in vitamin content may occur with radiation (Wolf, *et al.*, 1957).

HIGH-FREQUENCY ELECTRIC FIELDS

Stored-food insect control through selective heating by high-frequency (HF) electric fields has been accomplished experimentally (Watters, 1962). Both radiation and HF show promise as a method of eliminating insect eggs from stored grain.

BIOLOGICAL CONTROL

Parasitic wasps (*Anisopteromalus calandrae, Cephalonomia tarsalis, Bracon hebetor, Idechthis canescens,* etc.), fly larvae (*Omphrale fenestralis, Omphrale globrifrons,* etc.), and mites (straw itch mites, floricolus grain mites, etc.) prey on stored-product insects and can be effective in limiting an infestation. A crab spider, *Thanatus peninsulanus,* is commonly found preying upon stored food pests.

RECLAMATION

The term reclamation is used to denote the processing of materials in order to prevent losses. Hams infested by cheese maggots may be trimmed and repackaged in order to maintain them in a saleable condition. Cereal products may be fumigated and repacked in multi-wall sacks to prevent further damage. It is good practice to use multi-wall bags for cereal products that are to be shipped overseas to the tropics, holds of ships, making conditions favorable to insects. Military products are often stockpiled overseas under conditions which subject them to high temperature and humidity over a period of time.

AUDIOVISUAL AIDS

Available on free, short-term loan within the United States. Please indicate exact dates that films are to be used and allow ample time for shipment. Requests should be addressed to:

U.S. Public Health Service
Communicable Disease Center
Atlanta, Georgia, 30333

Attn: Public Health Service Audiovisual Facility

BIOLOGY AND CONTROL OF THE COCKROACH (FG–426), filmograph, 16 mm, color, sound, 489 feet, 13½ minutes, 1960.

COMMUNITY FLY CONTROL OPERATIONS (4–094), motion picture, 16 mm, black and white, sound, 12 minutes, 1952.

DOMESTIC VECTOR CONTROL BY BASIC SANITATION (SPF–296), filmstrip, 35 mm, color, sound, 49 frames, 6½ minutes, 1958.

EPIDEMIOLOGY OF MURINE TYPHUS (4–049.1), motion picture, 16 mm, black and white, sound, 18 minutes, 1953.

FLY CONTROL THROUGH BASIC SANITATION (4–090), motion picture, 16 mm, black and white, sound, 9 minutes, 1950.

FOOD SANITATION. PART 3: WASHING AND STORAGE (F–148k.3), filmstrip, 35 mm, color, silent, 65 frames, 1954.

IDENTIFICATION OF SOME COMMON FLEAS (F–101), filmstrip, 35 mm, black and white, sound 59 frames, 13 minutes, 1952.

NEW TECHNIQUES FOR REARING BLOOD-SUCKING INSECTS (F–98), filmstrip, black and white, silent, 31 frames, 1951.

ORGANIZED MOSQUITO CONTROL (M–191), motion picture, 16 mm, color, sound, 17 minutes, 1955.

RAT ECTOPARASITE CONTROL (M–37.1g), motion picture, 16 mm, black and white, sound, 8 minutes, 1954.

REFRIGERATED FOOD STORAGE PRINCIPLES (F–21b), filmstrip, 35 mm, black and white, sound, 62 frames, 12 minutes, 1951.

RURAL RAT CONTROL (4–116), motion picture, 16 mm, black and white, sound, 16 minutes, 1951.

SANITATION TECHNIQUES IN RAT CONTROL (M–37.1d), motion picture, 16 mm, black and white, sound, 12 minutes, 1954.

SANITARY STORAGE AND COLLECTION OF REFUSE (M–4), motion picture, color, sound, 19 minutes, 1952.

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Part 3. Centipedes. Pest Control, *27*(3) : 29.

Part 4. Spiders. Pest Control, *27*(4) : 30.

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